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A Comprehensive Framework for Off-Highway Vehicle Trail Management

Draft

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8E82A76—Best Management Practices for Assessing, Developing, and Maintaining Sustainable OHV/ATV and Multi-Use Trails and Systems

Cover figure—A sustainable OHV trail under construction in the White Mountains National Recreation Area, AK.

Contents

Acknowledgments

No trail manager walks an untrodden path. Many before us have blazed the technical aspects of trails, cleared the bureaucratic brush, and grubbed out inefficient methodologies to create a smooth tread for others to follow. I would be greatly remiss not to give credit to those who have contributed so greatly to my knowledge and understanding of trail management.

Don Beers (retired) and Karl Knapp of California State Parks have honed the science of trail management to a fine edge. After training with them in California and Alaska, I have tried to adapt and apply their concepts of sustainable design, layout, construction, and maintenance to the management of motorized trails.

I've also had the privilege of being mentored by Cam Lockwood and Keith Ginn of Trails Unlimited, a Forest Service enterprise unit. Cam and Keith's approach to trail management is decidedly pragmatic. They have trail dozers, and they know how to use them! These guys shared a wealth of practical trail knowledge from their work ranging from the subarctic to the Mexican border and from California to the Atlantic seaboard.

The International Mountain Bicycling Association (IMBA) has influenced my concepts of trail design and methods of trail education. Probably more than any other organization, IMBA has taken sustainable trail management concepts to the people. Their excellent publications, mobile trail care crews, and popular trail training programs have promoted sustainable trail concepts across the globe. I have adapted many of their mountain bike trail concepts to off-highway vehicle (OHV) trails.

Shifting from major influences to in-the-trench partners, Blain Anderson was my long-term trails partner at the U.S. Department of the Interior, National Park Service (NPS). Many of the management concepts and techniques described in this document were developed talking with Blain while responding to OHV issues on NPS lands in Alaska. Blain produced the bulk of the technical illustrations in this document. Because each illustration is worth a thousand words, he has been a major contributor to this report.

Another partner is Mike Shields, the "Old Trail Dawg." Mike cut his teeth on trails in the era of wooden ships and iron men, but doesn't have a spot of rust on him! Mike, a retired NPS chief of maintenance, is a master trail builder, bridge expert, blasting specialist, draftsman, illustrator, and educator. Mike has contributed broadly and liberally to this report.

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Finally, a big thank you to all of the folks who have advanced, are advancing, or will be advancing the art and science of sustainable trail management.

Chapter 1: Introduction

Management of OHV trails is one of the biggest challenges facing natural resource managers in North America today. The Forest Service, U.S. Department of Agriculture, has identified unmanaged OHV use as one of the four primary threats facing the national forests and grasslands. Widespread unauthorized and unmanaged use is damaging both public and private resources and fueling campaigns against OHVs.

The 10 elements of the management framework presented here will help OHV trail managers develop sustainable trails and protect the environment surrounding the trails. In addition, the framework will help OHV trail managers evaluate trail sustainability and develop OHV trail management programs that meet users' needs and expectations.

The framework provides a step-by-step approach to OHV trail management, incorporating sustainable design and management concepts with traditional trail management expertise and modern technological tools. The framework can be applied in part or in whole and applies whether you are constructing new trails or managing existing trail systems. The framework is especially helpful when you are initiating a management program for "orphan" trails—those trails that have never had any management whatsoever.

This management framework was field tested in a variety of settings, most often in Alaska, where the author is the regional trails specialist for the U.S. Department of the Interior, National Park Service (NPS), and a consultant for the NPS-Rivers, Trails, and Conservation Assistance Program (RTCA). Alaska has unique OHV management challenges, but the management framework presented here can be applied in a broad range of OHV trail management settings. An earlier report, "Managing Degraded Off-Highway Vehicle Trails in Wet, Unstable, and Sensitive Environments" (Meyer 2002), introduces some of the concepts developed here.

The Forest Service Trails Management Handbook (2309.18) defines an OHV as any motor vehicle designed for or capable of cross-country travel on or immediately over land, water, sand, snow, ice, marsh, swampland, or other natural terrain (36 CFR, Part 212.1). In this report, off-highway vehicles (OHVs) include everything from dirt bikes to swamp buggies—off-road vehicles (ORVs), off-highway motorcycles, all-terrain vehicles (ATVs), utility-terrain vehicles (UTVs), four-wheel-drive vehicles such as pickup trucks and sport utility vehicles, tracked vehicles, and mud bogging trucks. The legitimate use of OHVs is widely recognized by land management agencies, including the U.S. Department of the Interior, Bureau of Land Management (BLM), and the Forest Service, which have designated thousands of miles of OHV trails across national forests, rangelands, and other public lands. Other Federal agencies and many States and local authorities also provide OHV access across their lands.

Although this management framework does not specifically address safety issues involving operation of OHVs, land management agencies may require specialized training before their employees are allowed to operate OHVs. In addition, the agencies may have a number of other safety requirements for OHV operators, such as those detailed in the Forest Service's "Health and Safety Code Handbook" (FSH 6709.11, U.S. Department of Agriculture 1999).

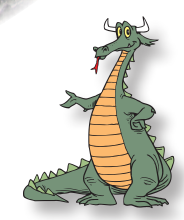
One of the management framework's primary objectives is to help managers develop sustainable trails. So what is a sustainable trail? According to American Trails, a national trail nonprofit organization, a sustainable natural surface trail is:

> "A trail that supports currently planned and potential future uses with minimal impact and negligible soil loss…The sustainable trail will require little rerouting and minimal maintenance over extended periods of time."

The National Interagency "Trail Management: Plans, Projects and People" training course (Beers 2009) defines a sustainable trail as:

> "A trail that has been designed and constructed to such a standard that it does not adversely impact natural and cultural resources, can withstand the impacts of the intended user and the natural elements while receiving only routine cyclic maintenance and meets the needs of the intended user to a degree that they do not deviate from the established trail alignment."

Regardless of how you define sustainable trails, managing trails for OHVs can be a lot like herding dragons. They're big, they can cause a lot of damage, and they sure can heat things up. Dragons can only be herded when you have a deep understanding of their nature. Trail managers can only be successful when they have a deep understanding of the nature of OHV trails, their users, and the surrounding environment.



Chapter 2: Sustainable Trail Design Guidelines

Draft

This report presents simplified guidelines for OHV trail design. The author was greatly influenced by the California State Parks' sustainable trail criteria in its draft (2009) trails handbook. The author also took into consideration the International Mountain Bicycling Association's (IMBA 2007) essential elements of sustainable trails ("Appendix A: IMBA's Essential Elements"). The result is the author's integrated set of six sustainable OHV trail design guidelines:

1. **Contour curvilinear alignment—**Align the trail so it runs along the natural contour of the terrain rather than abruptly crossing the contour.
2. **Controlled grade—**Strive for an average trail grade of 10 percent or less, and a defined maximum trail grade based on local soil and terrain conditions. Limit the length of the steepest segments to less than 100 feet and their combined length to less than 5 percent of the total trail length.
3. **Integrated drainage—**Integrate water control in the design and construction of the trail using outslope, grade reversals, and rolling grade dips to maintain the terrain's natural patterns of waterflow. Drainage structures should be spaced close enough to prevent water erosion on tread surfaces or at points of discharge.

   The very best drainage designs are those built into new construction. These include frequent grade reversals and outsloping the entire tread. The classic mark of good drainage is that it's self maintaining, requiring minimal care.
4. **Full bench—**Construct a full bench by cutting the full width of the tread into the hillside on native, undisturbed material and casting the excavated soil as far from the trail as possible.

   Full bench construction requires more excavation and leaves a larger backslope than partial-bench construction, but the trailbed will be more durable and require less maintenance. You should use full-bench construction whenever possible.
5. **Durable tread—**Provide a durable tread surface which commonly includes compacted mineral soil, imported capping material, bedrock, or a hardened tread surfacing.

   Providing a durable tread for OHVs trails is critical for sustainability. In some cases, durable tread can help meet the intent of sustainable trail design guidelines 1 through 4.
6. **Appropriate maintenance—**Conduct routine maintenance and periodic project work to ensure that the trail remains within its original design specifications.

Some sustainable trail design guidelines are illustrated in figures 2–1 through 2–5. Applying these guidelines ensures a high level of environmental protection and long-term utility of the trail and tread surface under most anticipated use and climatic conditions. The six sustainable trail design guidelines will be used throughout this report as criteria for evaluating the sustainability of planned and existing trails.

Figure 2–1—This multiuse trail in the Chugach National Forest illustrates contour curvilinear alignment, the first sustainable trail design guideline. Note how the trail crosses the slope along the topographic contour rather than running more directly up or down the slope. The sideslope location of the trail and its alignment encourage the natural force of gravity to carry water across the trail rather than directing it down the trail.

Figure 2–2—This OHV trail in the Bureau of Land Management's White Mountains National Recreation Area illustrates controlled grade and integrated drainage, the second and third sustainable trail design guidelines. Note how the trail slowly descends the sidehill. In this case, the grade never exceeds 10 percent and grade reversals (short, abrupt changes in grade) serve as integrated water control features. The ATV rider visible in the photo is traversing the bottom of one of the grade reversals.

Figure 2–3—Note the angle of the trail tool handle. It shows that the trail tread has outslope, one type of integrated drainage (the third sustainable trail design guideline). Outslope encourages water to flow across the trail. Unfortunately, functional outslope is usually lost on OHV trails when wheel ruts form. Grade reversals can help address this problem.

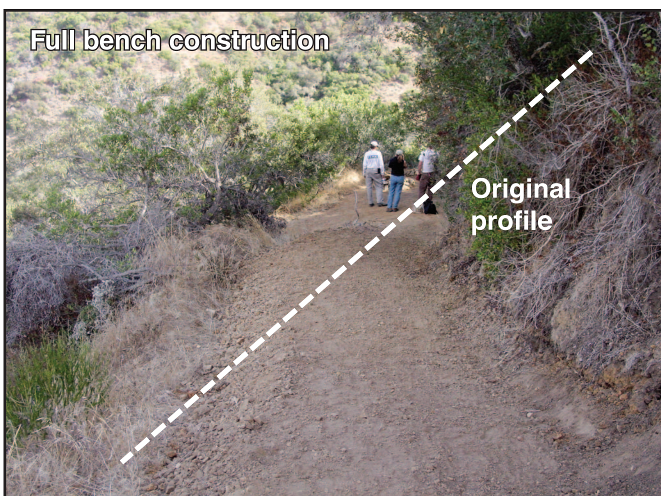


Figure 2–4—This profile of a Catalina Island, CA, foot trail illustrates full bench construction, the fourth sustainable trail design guideline. The dashed line indicates the original profile of the sideslope. Note how the entire slope has been excavated to ensure that the trail tread is supported by the most durable tread surface possible.

Figure 2–5—This figure illustrates the need for durable tread, the fifth sustainable trail design guideline. Even if contour curvilinear alignment, integrated drainage, and full bench construction are provided, some soils and environmental conditions require that surface tread receive extra attention. This photo, of a sustainable OHV trail alignment in Alaska's Chena River State Recreation Area, illustrates a tread surface that is excessively muddy when wet. Capping this area with gravel would ensure a durable wear surface under all climatic conditions.

The sustainable trail design guidelines provide OHV trail managers with a checklist for trail design, layout, and construction. The guidelines can help managers build trails that resist impact and are resilient when conditions change. Also, they can help trail managers identify design flaws in existing trails and predict whether the trails will hold up. The trail terms explained below are important for understanding the sustainable trail design guidelines. Appendix A also has background information on the sustainable trail design guidelines.

Trail Terms

The Half Rule (Controlled Grade)

Building sustainable trail grades helps keep maintenance at bay. So what makes a grade sustainable? The half rule (figure 2–6) is from "Trail Solutions: IMBA's Guide to Building Sweet Singletrack" (International Mountain Bicycling Association 2004).

This guideline really helps when putting trails on gentle sideslopes. For example, if you're working on a hill with a 6-percent sideslope, your trail grade should be no more than 3 percent. If the trail is any steeper, it will be a fall-line trail. Fall-line trails tend to capture and channel water, causing erosion and ruts.

As sideslopes get steeper than 20 percent, trails designed using the half rule can be too steep. A sustainable trail grade for any segment of trail can only be determined by a careful evaluation of site conditions such as soil type, hydrology, weather, tree canopy, and other site conditions.

Grade Reversals (Integrated Drainage)

A grade reversal (figure 2–7) is a short, distinct change in grade from ascending to descending (followed by a return to ascending). Sometimes, grade reversals are called grade dips, terrain dips, Coweeta dips, or swales. The basic idea is to use the reversal in grade to move water off the trail. Grade reversals are designed and built into new trails. A trail with grade reversals and outsloped tread encourages water to continue sheeting across the trail—not down it. The beauty of grade reversals is that they are the most unobtrusive of all drainage features if they are constructed with smooth grade transitions. Grade reversals require very little maintenance.

Grade reversals should be placed frequently, about every 75 to 125 feet. Take advantage of natural dips and draws when locating grade reversals.

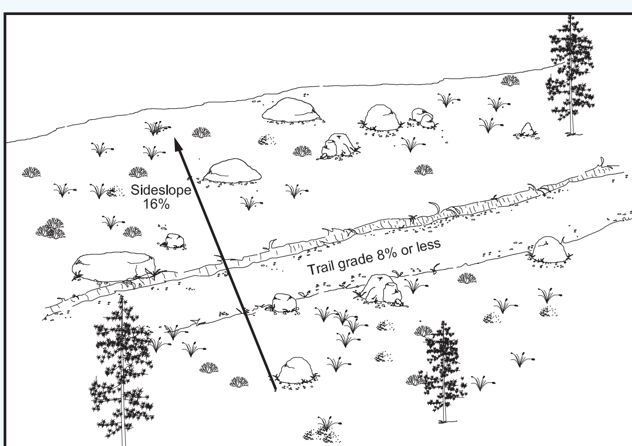


Figure 2–6—The half rule says that the trail grade should be no more than half the sideslope grade.

Figure 2–7—Grade reversals are much more effective than waterbars and require less maintenance.

Trail Terms (continued)

Rolling Grade Dips (Integrated Drainage)

Rolling grade dips (figure 2–8) are another way to direct water off existing trails. A rolling grade dip is typically constructed when maintaining existing trails.

A rolling grade dip is a constructed drain with a long ramp built on its downhill side (figure 2–9). For example, if a trail is descending at a 7-percent grade, a rolling grade dip includes a short dip, a climb of 10 to 20 feet at 5 to 10 percent, and a return to a descending grade down the constructed ramp. Water running down the trail cannot climb over the short rise and will run off the outsloped tread at the bottom of the drain. The beauty of this structure is that there is nothing to rot or be dislodged. Maintenance is simple.

Rolling grade dips should be placed frequently enough to prevent water from building up enough volume and velocity to carry your tread's surface away. Rolling grade dips are pointless at the top of a grade. Midslope usually is the best location. The steeper the trail, the more rolling grade dips will be needed. Rolling grade dips should not be constructed where they might send sediment-laden water into live streams. Appendix I has additional design information on rolling grade dips.

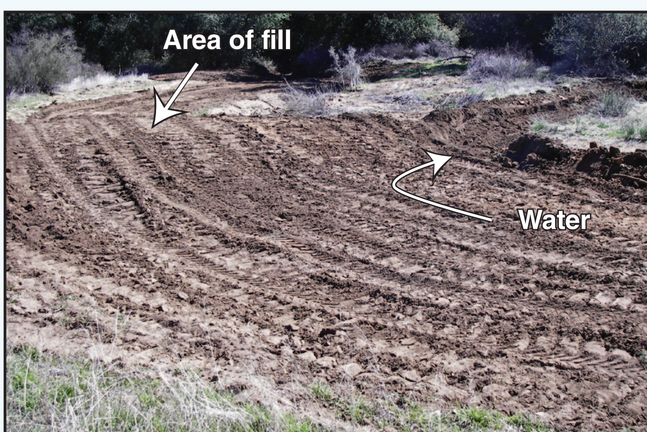


Figure 2–8—Rolling grade dips are constructed to direct water off existing trails.

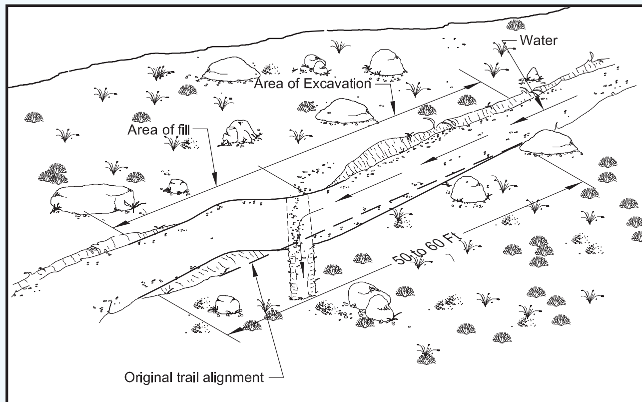


Figure 2–9—This drawing shows how to construct a rolling grade dip.

Outslope (Integrated Drainage)

Outslope is when the trail tread is shaped with a slight (5- to 10-percent) slant to the outside of the tread. This encourages water (sheet flow) from the slope above to flow across the trail and drain down the slope below. Outslope is a successful technique for managing water on foot trails, but outslope is difficult to maintain on wider trails required for OHVs. Motorized use quickly wears wheel tracks that capture and channel sheet flow down the trail. For OHV trails, grade reversals and rolling grade dips do a better job of controlling water than outslope.

Sheet Flow (Integrated Drainage)

When rain falls on hillsides, after the plants have all gotten a drink, the water continues to flow down the hill in dispersed sheets—called "sheet flow" (figure 2–10). All the design elements for a contour trail—building the trail into the sideslope, maintaining sustainable grades, adding frequent grade reversals, and outsloped tread—let water continue to flow across the trail where it will do little damage.

Trail Terms (continued)

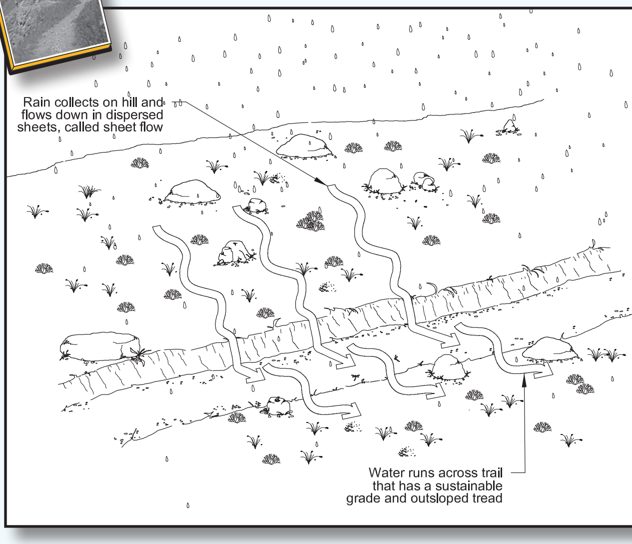


Figure 2–10—Design elements for a contour trail let water flow across the trail. Sheet flow prevents water from being channeled down the trail, where it could cause erosion.

—Adapted for OHV trails from the "Trail Construction and Maintenance Notebook" (Hesselbarth and others 2007).

Figure 2–11—An OHV trail adapted from a forestry road in south-central Alaska. Old roads and four-wheel-drive tracks provide ready access to the backcountry and are commonly adapted for OHV use.

Figure 2–12—An evolved OHV trail in the BLM's White Mountains National Recreation Area. The ridgetop rock outcrops have long drawn attention because they provide a great scenic view of the surrounding terrain.

Challenges of Applying Sustainable Trail Design Guidelines

Applying the sustainable trail design guidelines is relatively easy when constructing new trails, but two situations often confront OHV trail managers when they try to apply the guidelines to existing OHV trails:

- Few existing OHV trails meet all of the guidelines.
- Guidelines 1 through 4 do not apply if a trail is on flat terrain.

Many OHV trails began as old game or four-wheel-drive tracks that were adapted for OHVs, or evolved as riders continued following a set of OHV tracks that had been pioneered across the landscape. Figures 2–11 and 2–12 show an adapted trail and an evolved trail. Few of these trails were designed or constructed to any guideline, much less the six sustainable trail design guidelines. As a result, many of these trails degrade as use increases or when the types of use change over time.

For an existing trail to meet the first four sustainable trail design guidelines, the trail must be located on a sideslope. Sloped terrain is required for contour alignment, controlled grade, integrated drainage, and full bench construction. These design elements don't readily apply to flat terrain.

Trails on flat areas often have problems with tread entrenchment and water management. OHV traffic can easily wear and compact surface soils until they become entrenched (the tread is below ground level). Often water drains from the surrounding terrain and the trail becomes muddy. Muddy trails contribute to trail widening, ruts, and potholes, reducing the quality of the tread. In extreme cases, the degraded trail segments are avoided or abandoned by users, who develop new tracks around them—a condition referred to as "trail braiding." Figures 2–13 and 2–14 show examples of problems affecting trails on flat terrain.

Trails that cross flat terrain often require special trail design and construction methods to be sustainable. The fifth sustainable trail design guideline, durable tread, addresses this problem. Methods to provide durable tread for these trails are generally referred to as "trail hardening." Appendix B has additional information on trail hardening.

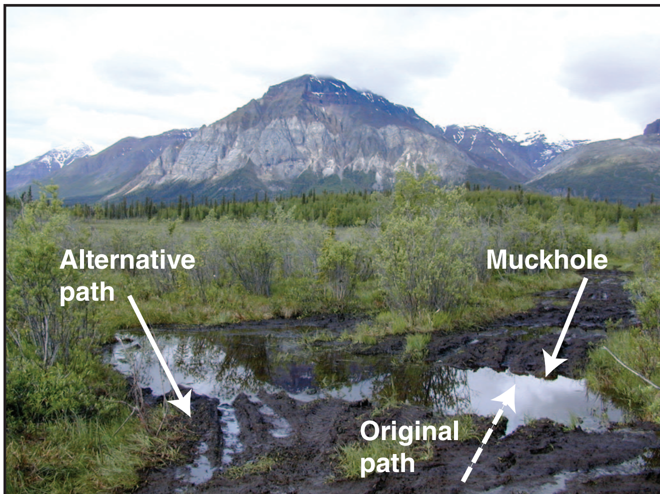


Figure 2–13—This OHV trail in Wrangell-St. Elias National Park and Preserve illustrates the problems of flat trails that cross permafrost terrain. Vehicle traffic has worn and compressed the surface cover until it collects and holds water. Repeated traffic has created deep muck holes and forced riders to create alternative paths around the degraded segment.

Figure 2–14—This trail on Alaska State land near Homer, AK, does not have permafrost, but the trail became muddy and rutted after traffic entrenched the trail relative to the surrounding terrain.

The Parts of a Trail

A **trail** is comprised of one or more **trail sections** that have multiple **trail segments.**

This report uses the following terms to describe a trail and its parts:

Trail—A linear route that typically connects a trailhead to a destination or junction or forms a loop route and is comprised of one or more trail sections.

Trail section—A portion of a trail with one or more segments that typically have the same trail class or general character. For example:

- A highly developed trail may have one section that serves a wide variety of users and farther along another less developed section serves a single group of users.
- A trail may be divided into sections when the trail crosses different types of terrain (such as floodplains, steep slopes, or extensive wetlands) requiring different types of tread management.

Trail segment—A short portion of a trail or trail section with similar physical characteristics such as tread width, grade, surface character, and so forth. For example:

- A portion of trail that has consistent grade, width, and surface material.

Significant changes in any of these characteristics require a new segment. Typically, a trail has dozens, if not hundreds, of individual trail segments. The number of identified segments depends on the complexity of the trail and the intensity of management.

Chapter 3: Trail Sustainability Categories

The sustainable trail design guidelines can help managers objectively evaluate the sustainability of OHV trails. The four trail sustainability categories used to define trails or trail sections are:

- **Design sustainable—**A trail or trail section that meets all six of the sustainable trail design guidelines. These trails seldom have degradation issues because these trails are well-designed.
- **Performance sustainable—**A trail or trail section that does not meet all of the sustainable trail design guidelines, but does not display any evident signs of degradation or loss of tread utility. This may occur when trails are lightly used or are used in ways that have low impact. Performance sustainable trails can only be expected to remain sustainable under the existing type of use, volume of use, and intensity of use—and only when weather is favorable. If conditions change, the sustainability of the trail can change abruptly.
- **Maintainable—**A trail or trail section that does not meet all of the sustainable trail design guidelines. With a reasonable level of improvement and regular maintenance, the trail can support a managed level of use without creating unacceptable environmental degradation or making the travel surface less usable.
- **Unmaintainable—**A trail or trail section that does not meet any of the sustainable trail design guidelines, is significantly degraded, and cannot reasonably be improved or maintained to protect environmental values or keep the trail surface usable at existing or even reduced levels and or types of use.

Figure 3–1—An example of a design sustainable trail section that meets all six of the sustainable trail design guidelines. This trail is in the Carnegie State Vehicular Recreation Area in central California.

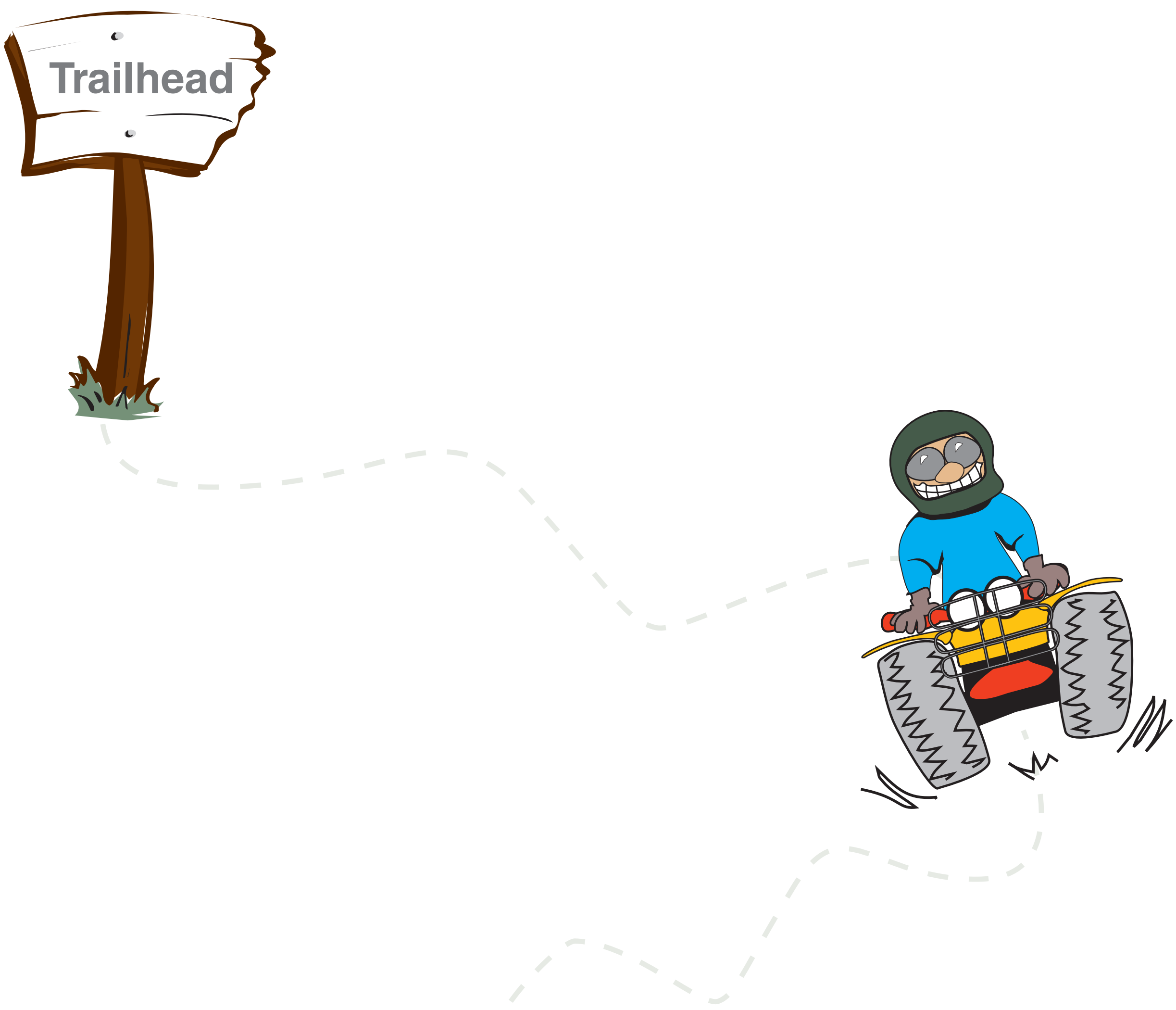
Figure 3–2—An example of a performance sustainable section of the Summit-Lake Miam Trail on Kodiak Island, AK. This section follows a ridgeline that has multiple segments of fall-line alignments. Because of low use levels there is little degradation, but continued or increased use could lead to erosion and rapid degradation.

These trail sustainability categories (figures 3–1 to 3–4) can help trail workers, agency managers, and the general public define the current status of a trail and predict its long-term utility. These categories will help managers evaluate management options, set priorities, and implement management decisions.

"Element 6—Evaluation of Management Options," discusses methods managers can use to sort trails into the four sustainability categories.

Figure 3–3—An example of a maintainable trail section in the Fortymile River area, AK. This section has a contour alignment and an average trail grade less than 10 percent, but lacks adequate water control. Rolling grade dips could be integrated into the alignment for increased sustainability.

Figure 3–4—An example of an unmaintainable section of trail in the Cleveland National Forest, CA. This section has none of the sustainable trail design elements and displays evidence of extreme trail degradation. The section has been closed and slated for reclamation.



Chapter 4: Trail Fundamentals

Many trail management concepts used by Federal land management agencies apply to OHV trails. Among these are five trail fundamentals refined and implemented by the Forest Service. Three of these fundamentals (indicated below with an "*") have also been adopted by the U.S. Fish and Wildlife Service, National Park Service (NPS), and BLM. The Forest Service trail fundamentals include:

- Trail type
- Trail class*
- Managed use*
- Designed use*
- Design parameters

These fundamentals help managers consistently record and communicate the **intended** design and management guidelines for trail design, construction, maintenance, and use. Additional information and training materials on trail fundamentals are available on the Forest Service's internal computer network at http://fsweb.wo.fs.fed.us/rhwr/ibsc/tr-fund.shtml.

Trail Type

The trail type indicates the predominant trail surface or trail foundation and the general mode of travel the trail accommodates.

Three trail types include:

Standard/Terra Trail—The predominant foundation of the trail is soil (as opposed to snow or water). The trail is designed and managed to accommodate travel on the ground.

Snow Trail—The predominant foundation of the trail is snow (as opposed to soil or water). The trail is designed and managed to accommodate travel on the snow.

Water Trail—The predominant foundation of the trail is water (as opposed to soil or snow). The trail is designed and managed to accommodate travel by watercraft. Water trails may include ground-based sections (portages).

Trail types are exclusive. Only one trail type can be assigned per trail or trail section so managers can identify specific trail design parameters (technical specifications), management needs, and costs for specific uses and/or seasons. A single physical route may accommodate a standard/terra trail during the summer and a snow trail during the winter. For administrative purposes, these would be considered two separate trails. In this report, OHV trails are considered standard/terra trails.

Trail Class

Trail class is the prescribed level of trail development, representing the intended design and management standards of the trail. Only one trail class is identified per trail or trail section:

- **Trail Class 1—**Minimally developed
- **Trail Class 2—**Moderately developed
- **Trail Class 3—**Developed
- **Trail Class 4—**Highly developed
- **Trail Class 5—**Fully developed

Appendix C presents the matrix of the five Forest Service trail classes.

The descriptions of the trail classes are meant to represent the typical development character of trails within that class. Exceptions for individual elements are allowed as long as the predominant character of the trail is in line with the trail class description.

There is a direct relationship between trail class and managed use: generally, one cannot be determined without considering the other (FSH 2309.18, sec. 14.30). Not all trail classes are appropriate for all managed uses. Figures 4–1 through 4–3 illustrate several trail classes for OHV, multiuse, and foot trails in Alaska.

Figure 4–1— This unnamed section of a minor developed OHV trail (Class 2) is on Kodiak Island, AK.

Figure 4–3—The Photo Point Trail is a fully developed foot trail (Class 5) at the Mendenhall Glacier, Juneau, AK.

Figure 4–2—The Powerline Pass Trail is an improved multiuse trail (Class 3) in Chugach State Park, AK.

Managed Use

Managed use is a mode of travel that is actively managed and appropriate on a trail, based on its design and management (FSH 2309.18, sec. 14.3). Managed use indicates a decision or intent to accommodate or encourage a specific type of trail use.

Each trail or trail section may have more than one managed use. The managed uses on a trail are usually a subset of all allowed uses. For example, a trail that is managed for ATVs and motorcycles may also allow mountain biking and hiking.

Designed Use

Designed use is the managed use of a trail that requires the most demanding design, construction, and maintenance parameters. The designed use, in conjunction with the applicable trail class, determines the design parameters that will apply to a trail (FSH 2309.18, sec. 14.4).

Each trail or trail section may have no more than one designed use. Although the trail may be actively managed for more than one use, and numerous uses may be allowed, the trail design is based on the single designed use. If a trail's managed uses are ATV and motorcycle riding, ATVs would be identified as the designed use because they have the most limiting design requirements (a wider tread and larger turning radius).

Forest Service Use Types

- Hiker/pedestrian
- Cross-country ski
- Pack and saddle
- Snowshoe
- Bicycle
- Snowmobile
- Motorcycle
- All-terrain vehicle
- Four-wheel drive vehicle more than 50 inches wide
- Motorized watercraft
- Nonmotorized watercraft

Design Parameters

Design parameters are technical guidelines for the survey, design, construction, maintenance, and assessment of a trail, based on its designed use and trail class.

Design parameters reflect the design objectives and determine the dominant physical criteria that most define the trail's geometric shape (FSH 2309.18, sec. 14.5). These criteria include:

- Tread width
- Surface
- Grade
- Cross slope
- Clearing
- Turns

The Forest Service has developed design parameters for each of the designed or managed uses in the list above. Figure 4–4 shows the Forest Service's design parameters for ATV trails. The Forest Service does not define ATV parameters for trail classes 1 and 5 because ATVs generally do not control the design for those classes of Forest Service trails.

Local deviations to the design parameters may be allowed based on specific trail conditions, topography, and other factors, provided that the variations continue to reflect the general intent of the trail classes. Grade variances should be based on local soils, hydrologic conditions, use levels, and other factors that contribute to erosion potential. Trail grades steeper than 10 percent should be evaluated carefully because of the likelihood of erosion and tread displacement.

The Forest Service design parameters can be adapted by other trail management organizations to fit their OHV management program. Any modifications should reflect the basic intent of the national trail classes. Table 4–1 presents a modified version of ATV design parameters developed by the author for use in Alaska. The modifications limit the design grades and include wider turn radiuses, guidance regarding water control, and sustainable trail design elements.

Designed Use ALL-TERRAIN VEHICLE		Trail Class 1	Trail Class 2	Trail Class 3	Trail Class 4	Trail Class 5
Design Tread Width	**Single Lane**	Typically not designed or actively managed for ATVs, although use may be allowed	48" – 60"	60"	60" – 72"	Typically not designed or actively managed for ATVs, although use may be allowed
	Double Lane		96"	96" – 108"	96" – 120"	
	Structures (Minimum Width)		60"	60"	60"	
Design Surface[2]	**Type**		Native, with limited grading May be continuously rough Sections of soft or unstable tread on grades < 5% may be common and continuous	Native, with some onsite borrow or imported material where needed for stabilization and occasional grading Intermittently rough Sections of soft or unstable tread on grades < 5% may be present	Native, with imported materials for tread stabilization likely and routine grading Minor roughness Sections of soft tread uncommon	
	Protrusions		≤ 6" May be common and continuous	≤ 3" May be common, but not continuous	≤ 3" Uncommon and not continuous	
	Obstacles (Maximum Height)		12" May be common or placed for increased challenge	6" May be common and left for increased challenge	3" Uncommon	

Figure 4–4—Forest Service National trail design parameters for ATV trails. —*From FSH 2309.18,"All-Terrain Vehicle Design Parameters," Trails Management Handbook (U.S. Department of Agriculture, Forest Service October 16, 2009).*

Designed Use ALL-TERRAIN VEHICLE		Trail Class 1	Trail Class 2	Trail Class 3	Trail Class 4	Trail Class 5
Design Grade[2]	**Target Grade**		10% – 25%	5% – 15%	3% – 10%	
	Short Pitch Maximum		35%	25%	15%	
	Maximum Pitch Density		20% – 40% of trail	15% – 30% of trail	10% – 20% of trail	
Design Cross Slope	**Target Cross Slope**		5% – 10%	3% – 8%	3% – 5%	
	Maximum Cross Slope		15%	10%	8%	
Design Clearing	**Height**		6' – 7'	6' – 8'	8' – 10'	
	Width (On steep sidehills, increase clearing on uphill side by 6" – 12")		60" Some light vegetation may encroach into clearing area	60" – 72"	72" - 96"	
	Shoulder Clearance		0" – 6"	6" – 12"	12" – 18"	
Design Turn	**Radius**		6' – 8'	8' – 10'	8' – 12'	

For definitions of Design Parameter attributes (e.g., Design Tread Width and Short Pitch Maximum), see FSH 2309.18, section 05.

[2] The determination of the trail-specific Design Grade, Design Surface, and other Design Parameters should be based upon soils, hydrological conditions, use levels, erosion potential, and other factors contributing to surface stability and overall sustainability of the trail.

Figure 4–4 (continued)

Table 4–1—Modified trail design parameters for ATV trails in Alaska. Trail classes 1 and 5 are not shown because they are not designed for ATVs as the primary user. —*Adapted from "All-Terrain Vehicle Design Parameters," FSH 2309.18, Trails Management Handbook (U.S. Department of Agriculture Forest Service October 16, 2008).*

Designed use: All-terrain vehicle		**Trail class 2 Simple/minor developed**	**Trail class 3 Developed/improved**	**Trail class 4 Highly developed**
Design tread width (If sideslopes are more than 50 percent, increase widths by 6 to 18 inches)	**One lane**	48 to 60 inches	60 inches	60 to 72 inches
	Two lane	Typically not designed for two-lane travel Passing areas (uncommon) 108 inches	Typically not designed for two-lane travel Passing areas (common) 108 inches	Two lane travel (common) 108 to 120 inches
	Structures (minimum width)	60 inches	72 inches	78 inches
Design surface	**Type**	Native with limited onsite barrow or imported materials Few loose or soft trail segments, commonly rough	Native with some onsite barrow or imported materials No loose or soft trail segments, occasionally rough	Native with extensive gravel, pavers, or other imported materials Firm and stable
	Obstacles	Rough with embedded rock, holes, and protrusions up to 6 inches	Generally smooth, with few protrusions exceeding 4 inches	Smooth with few obstacles exceeding 1 to 3 inches
Design grade[1]	**Target range** (more than 90 percent of trail)	Less than 15 percent More than 3 percent	Less than 12 percent More than 3 percent	Less than 10 percent More than 3 percent
	Short pitch maximum (up to 100-foot lengths—with appropriate water control above and within pitch)	25 percent on rock or bedrock 20 percent on soil	20 percent on rock or bedrock 15 percent on soil	15 percent
	Maximum pitch density[2]	Less than 15 percent of trail	Less than 10 percent of trail	Less than 5 percent of trail
Design tread cross slope	**Target range**	5 to 10 percent	3 to 8 percent	3 to 5 percent
	Maximum	15 percent	10 percent	8 percent
Design clearing	**Width** (on steep sidehills, increase clearing on uphill side by 6 to 12 inches)	12 inches outside of tread edge Some light vegetation may encroach into clearing area	12 to 18 inches outside of tread edge	More than 18 to 24 inches outside of tread edge
	Height	7 to 8 feet	8 feet	10 feet
Design turns	**Radius**	15 feet minimum	15 to 20 feet minimum	20 feet minimum
	Type	Climbing turns (switchbacks to be minimized)	Climbing turns (switchbacks only when absolutely necessary)	Climbing turns only
Water control[3]	**Type**	Grade reversals Dip drains Rolling grade dips No water bars	Grade reversals Dip drains Rolling grade dips No water bars	Grade reversals Dip drains Rolling grade dips No water bars
Sustainable trail design	**Elements**	Contour alignment Controlled grade Integrated drainage Full bench Durable tread	Contour alignment Controlled grade Integrated drainage Full bench Durable tread	Contour alignment Controlled grade Integrated drainage Full bench Durable tread

[1]Target and short pitch trail grades should be based on local soils, hydrological conditions, use levels, and other factors contributing to surface stability and erosion potential.
[2]Maximum pitch density refers to the percentage of the trail length that has the short pitch maximum grade.
[3]Water control structures should be spaced frequently enough to prevent water from eroding the tread surface.

Trail Design Factors

Trail use characteristics, site conditions, and climate and weather affect trail design, layout, construction methods, and maintenance. Figure 4–5 shows the relationship between these factors.

Trail use characteristics refer to the type, volume, intensity, and season of trail use (table 4–2). Use characteristics define the potential use and expected wear and tear on the trail tread and associated trail features.

Site conditions such as slope (or lack of slope), soil type, and local hydrology also affect a trail. As a trail crosses different landscapes, the surface soil, site hydrology, and terrain characteristics change. As these site conditions change, the site's natural ability to support trail use changes. Trail design and construction methods may need to be modified to reflect these changes.

Climate and weather also have a strong effect on trails. Trails in the northern latitudes have seasonal freeze and thaw cycles. Trails in southern latitudes may have predictable dry or wet seasons. Local weather events, regardless of the climate, are important considerations. These events include precipitation frequency, intensity, and volume.

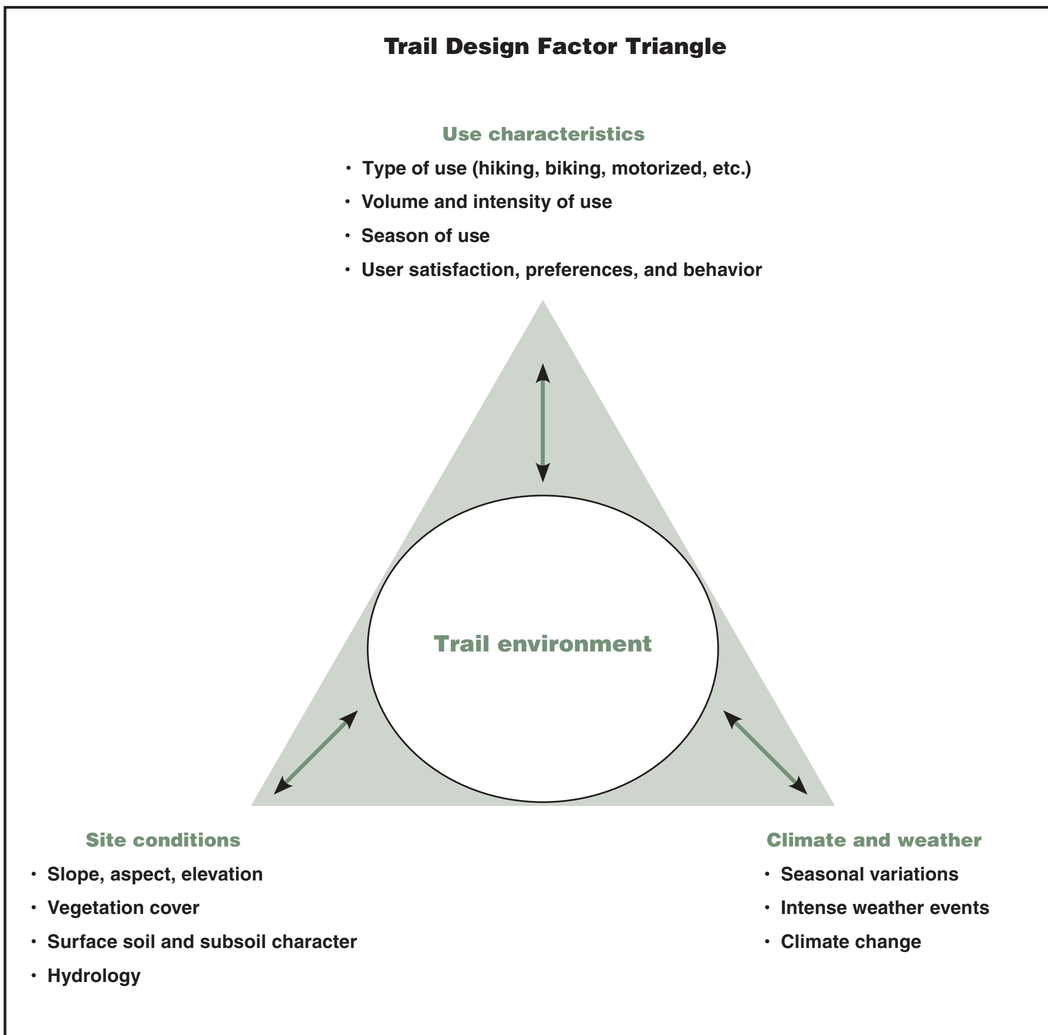


Figure 4–5—The relationship between trail design factors (use characteristics, site conditions, and climate and weather) affect the trail environment. These factors need to be considered during trail design, layout, construction, and maintenance.

Table 4–2—OHV use types and characteristics.

Type of OHV	Typical length (feet)	Minimum (optimum) turn radius required (feet)	Width (feet)	Tread width (feet)	Standard clearing width[1] (feet)	Minimum required clearing height (feet)	Typical speed (mph)	Average sight distance[2] (feet)	Typical weight range when loaded (pounds)	Approximate pounds per square inch (PSI)	Load on tread	Torque delivered to tread surface	Type of turns	Potential tread displacement[3] on flats (less than 8 percent)	Potential tread displacement[4] on grades (more than +8 percent)	Typical weight range when loaded (pounds)
Off-highway motorcycle	5 to 6	10 (15)	1.6	2	1.5 to 2.0	8	10 to 40	160	400 to 550	17 to 18	High	High	Super-elevated	High	High	400 to 550
ATV	8	15 (20)	4.0	5	2.0	8	5 to 25	80	800 to 1000	10 to 12	Mod-erate	Low to mod-erate	Super-elevated	Mod-erate	Mod-erate	800 to 1000
UTV	8 to 10	20 (24)	5.0	6	2.0	10	5 to 20	70	1,600 to 1,900	16 to 20	Mod-erate	Mod-erate to high	Flat	Mod-erate	Mod-erate	1,600 to 1,900
4-wheel-drive vehicle	14 to 19	25 (30)	6.0 to 7.0	8 to 9	3.0	10	5 to 25	80	2,400 to 6,400	16 to 30	High	Mod-erate to high	Flat-banked	Mod-erate to high	High	2,400 to 6,400
Light tracked vehicle[5]	8 to 16	20 (25)	4.0 to 6.0	7 to 8	2.0	10	3 to 12	30	1,300 to 2,900	3 to 4	Low	Very low	Flat	Low	Low	1,300 to 2,900
Heavy tracked vehicle[6]	16 to 24	30 (35)	7.0 to 10.0	9 to 12	3.0	12 to 14	3 to 8	30	2,900 to 20,000+	3 to 8	Low	Very low	Flat	Low	Low	2,900 to 20,000+
Unlimited bogger[7]	16 to 24	30 (35)	7.5	9 to 12	3.0	12 to 14	5 to 15	50	6,400 to 10,400	18 to 27	High	Mod-erate to high	Flat	Mod-erate	Mod-erate	6,400 to 10,400

Note: Structures on OHV trails require load specific design per span.

[1]May be desirable to narrow clearing widths to reduce speed for certain uses.
[2]Sight distance should be set based on the highest shared use. Figures are based on response to oncoming traffic. If speed is reduced through tread design (increased sinuosity or obstacles), the sight distance may be reduced.
Always assume two-way traffic.
[3]Rutting of moist to saturated tread.
[4]Downhill displacement of tread material.
[5]Tracked ATVs, tracked-equipped Argos, Weasels, tracksters, Centaur.
[6]Nodwells, Foremost.
[7] Modified 4-wheel-drive pickups and 2.5-ton trucks with large tires.

Chapter 5: Trail Management Framework

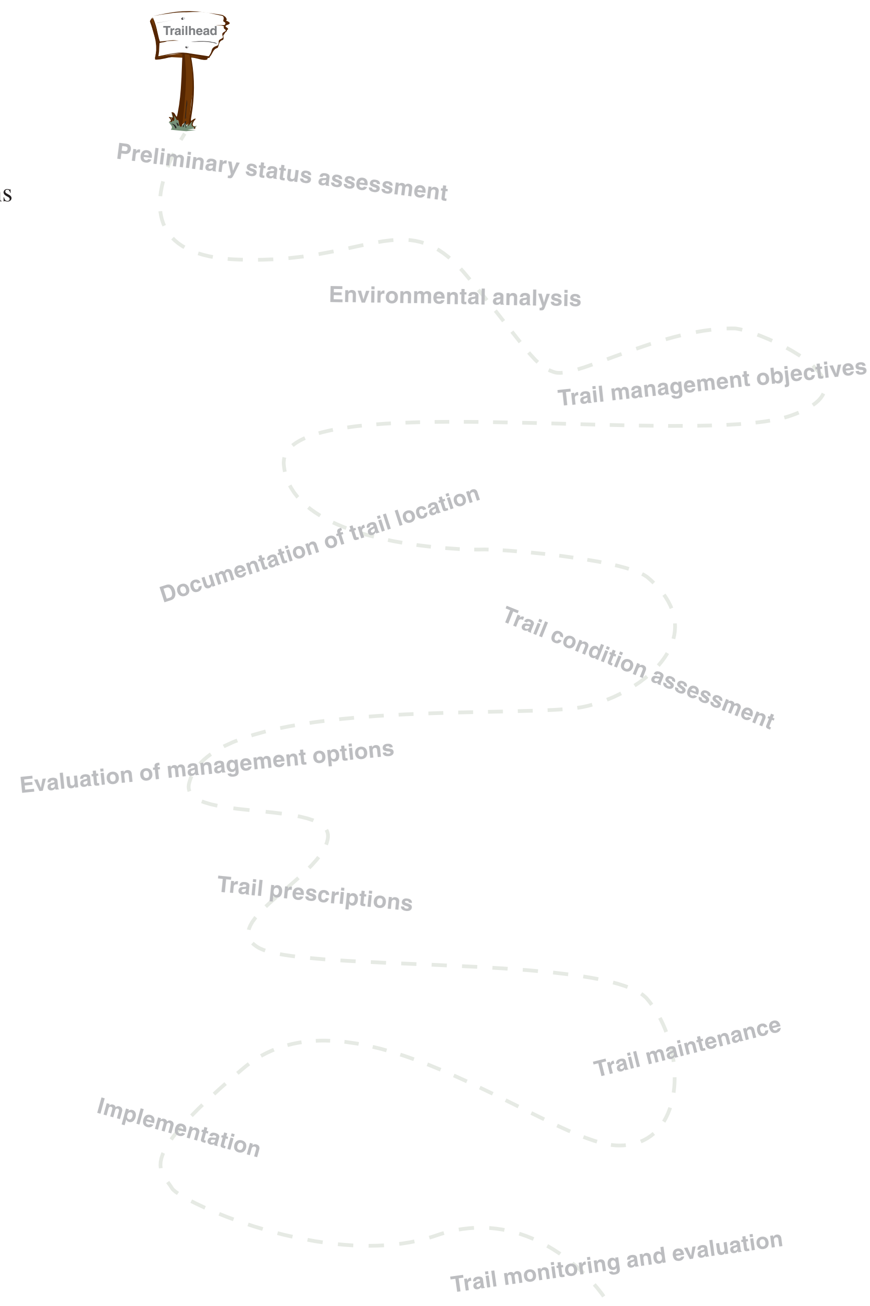
A 10-element management framework allows the basic trail sustainability elements to be applied systematically. Taken together, the 10 elements provide managers with guidance on information collection, data evaluation, decisionmaking, and program development and implementation.

The 10 trail management elements are:

- Preliminary status assessment
- Environmental analysis
- Trail management objectives
- Documentation of trail location
- Trail condition assessment
- Evaluation of management options
- Trail prescriptions
- Trail maintenance
- Implementation
- Trail monitoring and evaluation

The basic components of each of the 10 elements have been developed and refined—in one form or another—by trail professionals over the decades. These elements can be applied in sequence when a new management program is being developed or when OHV trails have had little administrative oversight. When a trail is already being actively managed, certain elements of the framework may be of greater value than others.

Each of the 10 trail management elements is discussed in more detail in the chapters that follow.



Chapter 6: Element 1—Preliminary Status Assessment

A preliminary assessment is a snapshot of the trail status, based on readily available information. This assessment is particularly useful when little is known about a trail, its environment, or its management history. If trails have had a long history of active management, a preliminary assessment may not be required. A preliminary status assessment provides information on the:

- Administrative status of a trail
- Management status of a trail
- Trail use characteristics
- Related environmental issues and concerns

Table 6–1 shows a preliminary status assessment for the fictional Orphan Trail system. The table allows data for two different trails to be compared quickly. The table can be modified to fit any management scenario or administrative need. Developing such a table will help managers identify data gaps, inconsistencies in management between different trails, the status of agency oversight, and general problems with the trail alignment. The table provides a convenient reference for communication among agency employees, trail users, and the general public.

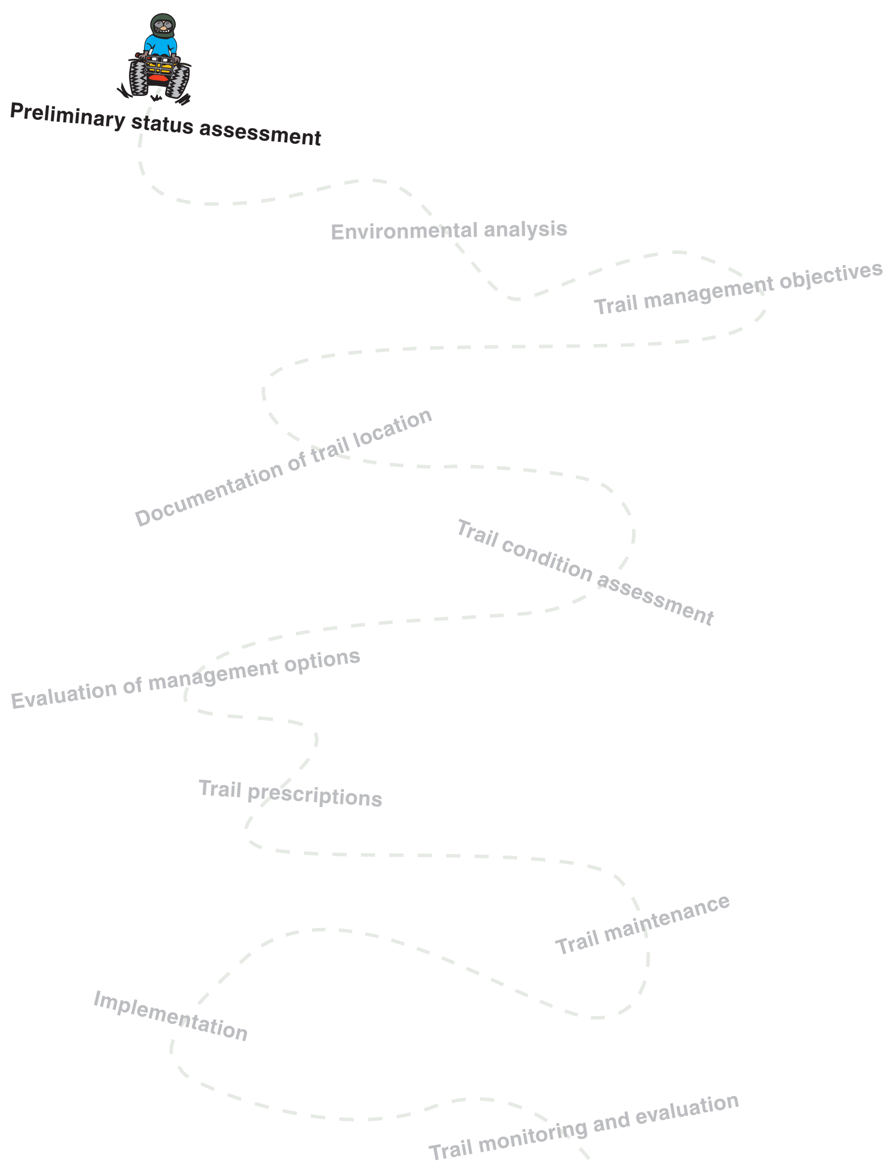


Table 6–1—A preliminary status assessment for the fictional Orphan Trail system. GIS stands for geographic information system and GPS stands for global positioning system.

Administrative unit name: Orphan Trail System	Annie Trail	Andy Trail
Administrative details		
Length of the route	6.5 miles	About 21 miles
Land ownership	State	State, county
How was the trail developed?	Users	Former forestry road
Is there management oversight?	No	No
Is the route alignment accurately mapped?	Yes, GPS survey 2002	No
Is the alignment data plotted on GIS?	Yes, county trails database	No
Are on-the-ground management actions occurring?	Yes, minor infrequent user improvements	None to date
Are any planning actions pending?	Yes, county roads plan	Yes, county roads plan
Are there trailhead improvements?	Yes, informal parking area	None, trail junction off county road
Is the route signed?	Yes, user-created signs at junction, a few reassurance markers along route	No
Are route maps or directions available to the public?	Yes, appears on county maps	No
Use characteristics		
Types of OHVs used	ATVs, motorcycles	2-wheel-drive ATVs, 4-wheel-drive ATVs, Jeeps
Purpose of use	Recreational	Recreational, hunting, access to inholding
Approximate use levels	200 or more passes/week	Unknown, estimated as relatively light
Intensive use periods	Weekends, 4th of July fun run	Hunting season
Other uses	Mountain bikers, horse riders, walkers, local runners	Mountain bikers, local trail runners
Use level trends over the past 5 years		
Motorized use	Increasing	Unknown
Nonmotorized use	Stable	Increasing
Other issues or concerns		
Are there vegetation related issues or concerns?	Yes, invasive species mile 0 to 1.5	Yes, illegal timber cutting near the trailhead
Are there impacts to water quality?	Yes, at 3-mile ford	Unknown
Are there wildlife issues or concerns?	None known	Yes, eagle nest site near mile 8.5
Are there impacts to fisheries?	Yes, fish habitat impacts at 3-mile ford	Unknown
Are there tread degradation issues or concerns?	Yes, ruts and erosion of tread between miles 4 and 5, muddy conditions at crossing sites, few water control structures	No, trail is generally in good condition
Physical condition trends over the past 5 years	Deteriorating	Stable
Are there conflicts with other users?	Yes, motorcycles and horse riders	No
Are there conflicts with private property owners?	No	Yes, private cabin holder reports break-ins and trash
Are there trespass or other law enforcement issues?	No	Yes, above

The preliminary assessment can be an internal agency effort or it can be adapted to a public process. The public may be an important source of information, particularly when the trail has little formal management history. Public input can help to identify existing and potential trail users and their expectations and concerns. Public input can be collected in various ways. The setting can be a formal facilitated meeting (figure 6–1). Users may also be contacted in the field while they are using the trail (figure 6–2). User surveys (figure 6–3) administered to a broader, more representative sample of users can also provide important information to managers.

Figure 6–1—Public meetings can help facilitate data gathering for a preliminary status assessment.

Figure 6–2—Public contacts made in the field can provide valuable information on use characteristics and user expectations. Here the author visits with ATV riders on an OHV trail converted from a fireline in the Chena River State Recreation Area, AK.

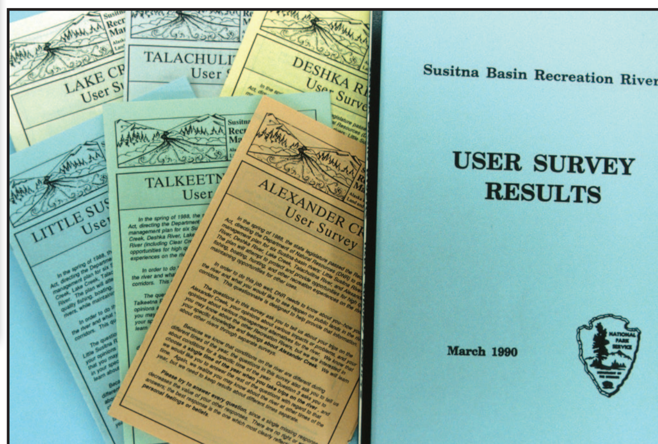


Figure 6–3—Formal user surveys and planning documents are an important source of information for a preliminary status assessment.


Hooper Bay Community Transportation
November 6, 2007

Chapter 7: Element 2—Environmental Analysis

This element documents the impacts, issues, and concerns that OHV trails and their use pose for the surrounding human and natural environment.

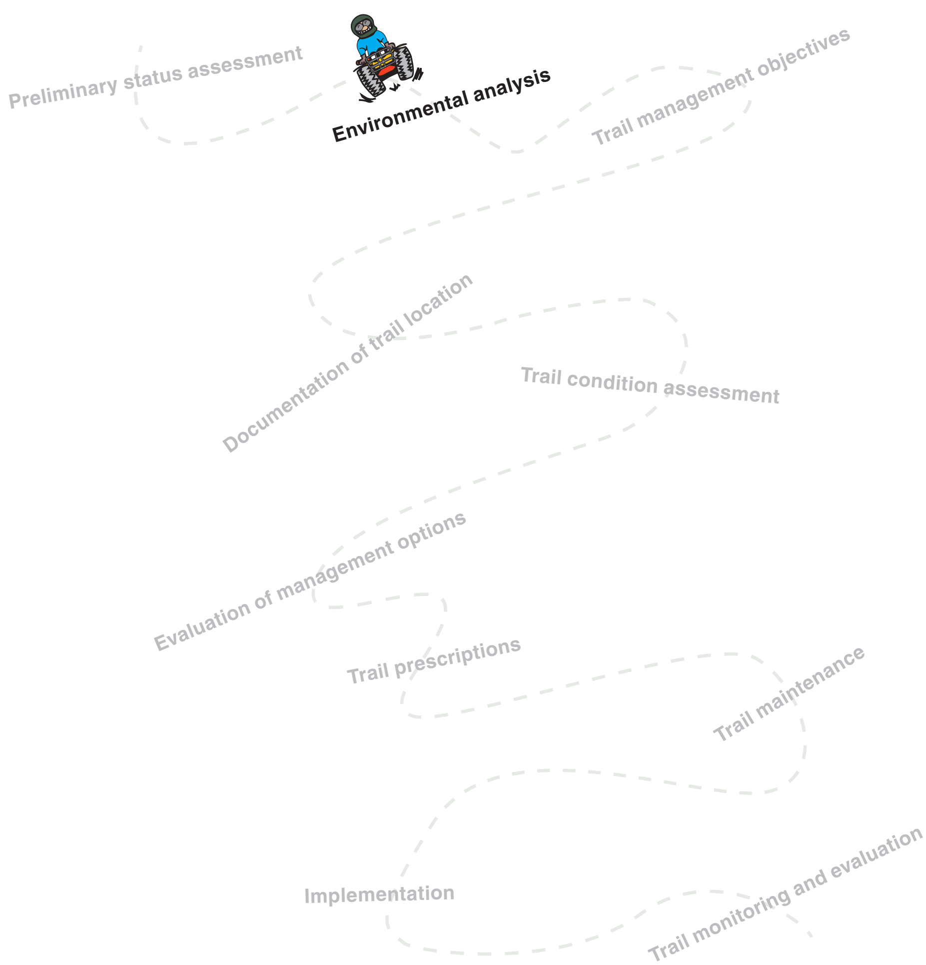
Robert Birkby describes a trail in "Lightly on the Land: the SCA Trail Building and Maintenance Manual" (Birkby and the Student Conservation Association 2005):

> "At its most basic, a trail is simply a cleared travel corridor leading from one point to another. While it can be a key tool for resource protection, a trail is also a scar on the landscape, a sacrifice zone devoid of vegetation, a linear clear-cut that can amount to a third of an acre or more per mile. And, yet we accept the denuded surface of a pathway as an almost natural part of the backcountry. It serves our needs extremely well, and by concentrating human use to a thin ribbon of tread, it can spare the larger landscape from being trampled."

Environmental analysis attempts to identify the impacts and concerns associated with the trail. The sustainable trail design guidelines attempt to minimize those impacts, but any trail—no matter how carefully designed, built, and maintained—will affect the surrounding environment. This is especially true for motorized trails. Concerns arise from:

- The introduction of internal combustion engines into the backcountry with their associated noise and exhaust.
- Requirements for wider tread—covering three-fourths of an acre or more per mile.
- The effect OHVs have on other trail users—helmets and armor make OHV riders appear alien and may limit their ability to communicate and interact with other users.
- The nature of the machines—their size and weight, noise, and their ability to displace tread material, travel at high speed, and cover long distances.

Concerns for planned and existing trails include administrative, social, biological, and physical effects.



Concerns for Environmental Analysis

Administrative

- Multijurisdictional land ownership
- Rights-of-way and easements—status and compliance
- Agency trail management organization
- Skills, time, and resources the agency can commit to on-the-ground trail management
- Local users or nonprofit organizations involved with trail management or maintenance

Social

- Motorized user concerns, expectations, satisfaction, and behavior
- Nonmotorized user concerns, expectations, satisfaction, and behavior
- Allocation conflicts among user groups—locations and miles of trails available for distinct user groups
- Changing use trends
- Trespass on private lands
- Littering, graffiti, vandalism
- Human waste
- Illegal timber cutting and other illegal activities
- Development of social trails
- Noise generation, exhaust, air pollution, fuel and oil spills
- Illegal parking at trailheads
- Inadequate trailhead facilities
- Poor signage
- Health and safety—speed issues, tread design, and trail hazards

Biological

- Impacts to vegetation
- Sedimentation or alteration of wetland vegetation
- Wildlife displacement
- Wildlife habitat loss and fragmentation
- Increased hunting pressure
- Impacts to fisheries habitat at stream crossings
- Impacts to fisheries from overuse
- Impacts to sensitive species
- Introduction of invasive plants

Physical

- Trail braiding
- Tread surface erosion
- Effects on air quality, including increased dust
- Effects on bridges
- Accelerated melting of permafrost
- Soil compaction, entrenchment, and ponding
- Erosion and sedimentation
- Impacts to cultural or archeological values
- Visual impacts
- Modification of the site's hydrology
- Water quality impacts (direct impacts at crossings, indirect impacts from drainage off adjacent trails
- Stream diversion or stream capture
- Drainage, creation, or modification of wetlands
- Destabilization of natural slopes and riverbanks
- Climate change

A few of these issues and concerns are illustrated in figures 7–1 through 7–4.

Concerns for Environmental Analysis (continued)

Figure 7–1—ATVs ford a degraded water crossing. Such sites impact water quality and fisheries values.

Figure 7–3—Protecting wildlife and the quality of its habitat should be an important trail management concern.

Figure 7–2—Cultural sites provide both opportunities for historic interpretation and concerns for protection.

Figure 7–4—Avoiding impacts to threatened, endangered, or sensitive plants should always be a trail management concern.

A valuable reference for environmental analysis is "Best Management Practices for Off-Road Vehicle Use on Forestlands: A Guide for Designing and Managing Off-Road Vehicle Routes" (Switalski and Jones 2009), which also includes best management practices (BMPs) for planning, decisionmaking, implementation, and monitoring trail projects. The guide is available at the Wildlands CPR Web site (http://www.wildlandscpr.org). An adapted version of the BMPs is in appendix D.

Environmental analysis covers a broad area of natural resource, social science, and engineering specialties. A trail manager needs to enlist the assistance of planning professionals, as well as agency interdisciplinary specialists (figure 7–5). Their skills can be essential for identifying issues and developing mitigation strategies that resolve management concerns. Table 7–1 shows how sustainable trails evaluation criteria can be applied during environmental analysis.

Although environmental analysis is described as a distinct element within the framework, a lot of environmental analysis needs to be done in other elements as well. For example, many administrative and social issues can be worked out early on when developing land use, travel management, or recreation resource plans. These broader planning efforts will help direct the development of trail management objectives (TMO) discussed later in this report. Similarly, during design and layout, environmental analysis may be needed to assess impacts at stream crossings and other sensitive sites. Field visits with resource specialists can help trail managers understand site-related environmental issues and assist in developing appropriate mitigation methods (figure 7–6). Other environmental concerns, such as use conflicts, may have to be handled as they arise (figure 7–7).

Figure 7–5—Resource staff should be enlisted and engaged to identify resource conflicts and opportunities related to trail management.

Table 7–1—Sustainable trails evaluation criteria applied to environmental analyses. —*Adapted with permission from Trail Management: Plans, Projects and People training course (Beers 2009).*

Sustainable trails are designed and constructed so they:
Do not adversely affect natural and cultural resources
Impacts that would be considered "take" are avoided and impacts that are considered "sensitive" are mitigated through the planning and environmental review process.
Do not disrupt or alter the natural hydraulic flow patterns of the landform
Sheet flow runoff is not diverted or accumulated and is allowed to continue on its normal flow path. No drainages (including microdrainages) are captured, diverted, or coupled with other drainages by the trail. Water is not accumulated on the trail and drained off onto the landform where natural drainages do not exist.
Can withstand 25- to 100-year storm events
The trail tread and structures are unaffected by these storm events. This includes impacts above and below the trail.
Meet the needs of the intended user group or groups
The intended user group stays on the designated trail and does not create unauthorized paths or volunteer trails. There is no significant reduction of trail use.

Figure 7–6—Resource specialists conduct a site visit at the Chena River State Recreation Area, AK, to identify problems and develop solutions for resource issues and concerns.

Figure 7–7—Use conflicts may arise at any stage of trail management. Identifying the potential for those conflicts early in the process and developing a management program that addresses the issues will pay off throughout the lifetime of a trail.

Environmental Compliance

The information collected during environmental analysis will provide critical information for any environmental assessment (EA), environmental impact statement (EIS), or other agency environmental compliance document prepared for a trail project or trail management plan.

Typically, interdisciplinary specialists within an agency would prepare data on impacts or concerns or a third party would prepare the EA, EIS, or other environmental document. The trail manager plays an important support role by providing accurate trail location data, any pertinent information collected during condition assessments, or assessments of natural, social, or cultural issues, and descriptions of mitigation options. Some examples of information the trail manager might provide include public safety issues, the presence of trail hazards, trail conditions, trail trends, and trail sustainability.

Table 7–2 provides a starting point managers can use when searching for sources of information on trails. After collection, data needs to be organized, evaluated, and displayed, possibly as georeferenced data on a map or in a geographic information system (GIS). Some examples are illustrated in figures 7–8 and 7–9.

Table 7–2—Information sources on trail issues and concerns: administrative, social, biological, and physical.

Administrative	
Topic	**Sources of information**
Multijurisdictional land ownership	Agency land status plats City/county platting departments
Right-of-way status	State records office for property deeds State and Federal land status plats City/county platting departments
Character of agency trail management within the organization	General management plans Transportation or recreation plans Trail management objectives Facility managers, trail crews
Level of agency on-the-ground trail management	Trail maintenance records Facility managers, trail crews
Local user involvement with trail management or maintenance	Trail maintenance records Facility managers, trail crews Local newspaper coverage Transportation or recreation plans—public comments Trail management objectives—public comments Rangers, trail crews Meetings with user groups
Social	
Topic	**Sources of information**
Direct user conflicts Conflicts between user groups	Local newspaper coverage Complaints to land managers, rangers, etc. Trail management objectives—public process Law enforcement actions Meetings with user groups Interaction with users on the trail or at trailheads
Trespass on private lands Illegal parking at trailhead Illegal activities	Agency and local law enforcement actions Ranger reports Public comments
Development of social trails	Condition assessments Monitoring products Trail crews Visual inspection
Littering	Trail crews Visual inspection
Noise generation	Public comments Monitoring efforts by agency Ranger reports and enforcement actions
Inadequate trailhead facilities Poor signage	Public comments Trail crews Rangers, resource specialists Monitoring Site inspections
Health and safety	Condition assessments and monitoring Public comments Ranger reports and enforcement actions Trail crews Visual inspection

Table 7–2—(continued)

Biological	
Topic	**Sources of information**
Impacts to vegetation from off-trail use	Condition assessments and monitoring Visual inspection Plant ecologist assessments Trail crews and rangers
Impacts to wetland communities from sedimentation	Visual inspection Monitoring Plant ecologist assessments Trail crews and rangers
Illegal timber cutting	Ranger reports and enforcement actions Visual inspection
Wildlife displacement and habitat fragmentation	Wildlife biologist assessments Centerline overlays on habitat maps
Increased hunting pressure	Wildlife biologist assessments State game managers/boards Public comments
Impacts to fisheries habitat at stream crossings	Fisheries biologist assessments Condition assessments Centerline overlays on fisheries habitat maps Trail crews
Impacts to fisheries from overutilization	Fisheries biologist assessments State game managers/boards Public comments
Impacts to sensitive species	Plant ecologist assessments Centerline overlays on plant habitat maps
Physical	
Topic	**Sources of information**
Duplicative trail routes Soil erosion	Centerline map products Condition assessments Visual inspection Monitoring Trail crews and rangers
Air quality and dust	Visual inspection Monitoring Public comments Trails crews and rangers
Accelerated melting of permafrost	Soil scientist/geologist assessments Condition assessments Visual inspection Monitoring Trail crews and rangers
Soil sedimentation—terrestrial and aquatic impacts	Fisheries biologist/resource specialist assessments Condition assessments Monitoring Visual inspection
Bridge structures	Agency engineer assessments Forest Service bridge design specifications Trail crews
Impacts to cultural or archeological values	Cultural resource specialist assessments Centerline overlays on cultural feature maps
Visual impacts	Visual resource/viewshed analysis Public comments
Microhydrology modifications Water quality impacts Stream diversion Wetland drainage	Hydrologist assessments Condition assessments Trail crews and rangers Monitoring

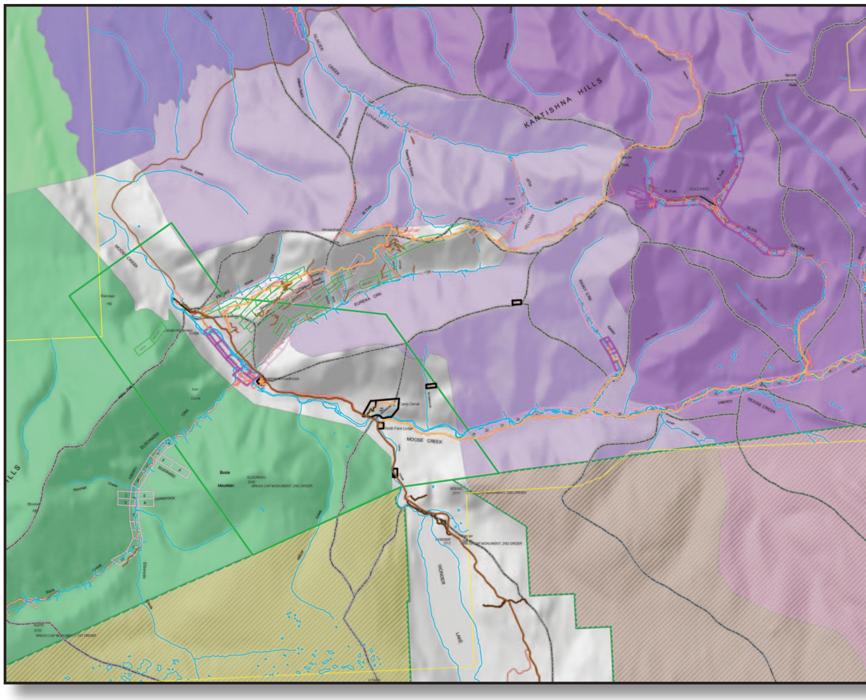


Figure 7–8—A GIS data display of administrative boundaries (parklands, backcountry units, and mining claims) and watersheds over a shaded relief topographic base map.

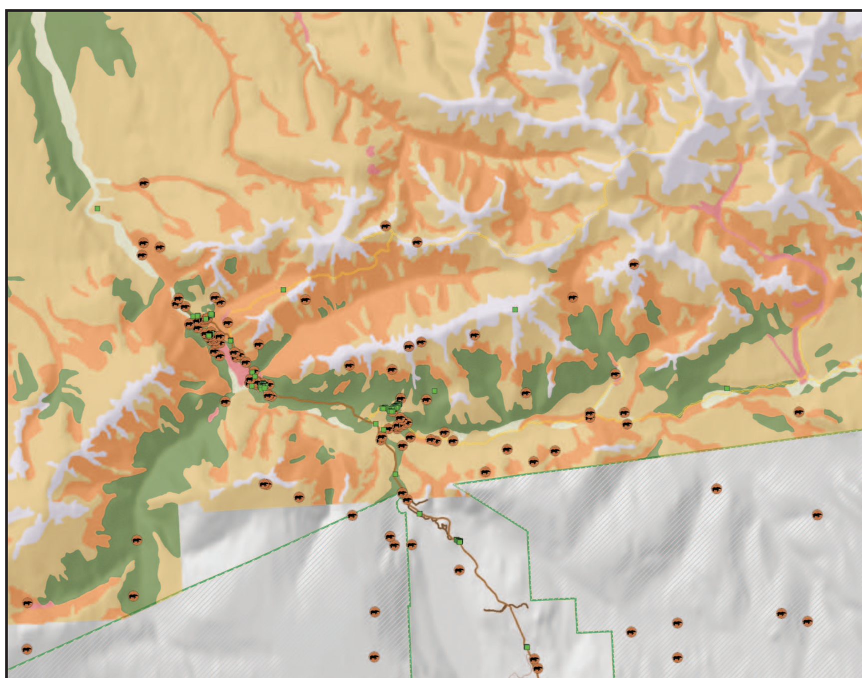


Figure 7–9—A GIS data display of vegetation cover, wildlife sightings (bears), and trail structure locations over a shaded relief topographic base map.

Chapter 8: Element 3—Trail Management Objectives

Trail management objectives (TMO) describe the **desired** management and condition of the trail, which may or may not coincide with the **existing** management and condition of the trail. The TMO identifies basic trail information, including the intended use of the trail, trail-specific design parameters, schedules for routine tasks, and special considerations. TMOs are essential for effective trail management and should be developed for all trails.

Depending on the situation, draft TMOs can be developed to provide initial guidance while additional information is collected, management options are considered, and final management direction is determined. Final TMOs should be reviewed and approved by an agency line officer and subjected to periodic review and modification as necessary.

After a TMO has been developed, it is the primary document that guides trail design, assessment, prescription, construction, maintenance, and monitoring for agency and trail managers, trail crews, contractors, and cooperating partners.

The Forest Service developed TRACS (Trail Assessment and Condition Surveys) to provide an approach for the consistent collection of trail inventory, condition, and prescription data. The "TRACS Trail Management Objectives" form also has been used by other agencies and can be adapted to meet agency-specific needs.

The Forest Service's TRACS TMO Form

The Forest Service's TRACS TMO form is divided into seven parts including overall trail information, TMO Trail Section, Designed Use Objectives, Travel Management Strategies, Special Considerations, Remarks/Reference Information, and Line Officer Approval. The entire form can be found in appendix E. Each part is discussed in more detail below.

Part 1—Overall Trail Information

The first part (figure 8–1) of the TMO form provides space where users can record basic trail information.

If the management objectives change along the trail, use the TMO Trail Section block to number and identify the TMO trail section being described. For example, a trail should be divided into two TMO sections—each with its own TMO—if the trail is managed as a highly developed class 4 trail for a given number of miles before being managed as a more challenging class 2 trail.

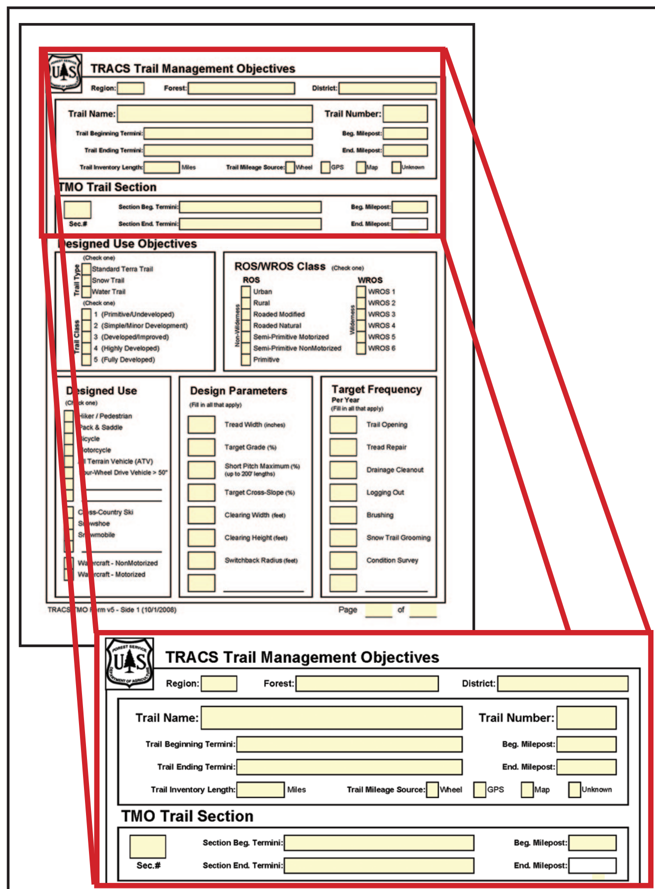

TRACS Trail Management Objectives
Region: Forest: District:
Trail Name: Trail Number:
Trail Beginning Termini: Beg. Milepost:
Trail Ending Termini: End. Milepost:
Trail Inventory Length: Miles Trail Mileage Source: Wheel GPS Map Unknown
TMO Trail Section
Sec.# Section Beg. Termini: Beg. Milepost:
Section End. Termini: End. Milepost:

Figure 8–1—Part 1 of the TRACS TMO form. —*TMO form from "TRACS: Trail Assessment & Condition Surveys 2008 User Guide" (U.S. Department of Agriculture, Forest Service 2008).*

Part 2—Designed Use Objectives

The second part (figure 8–2) of the TMO form has five blocks for the designed use objectives that guide trail planning, design, construction, maintenance, and monitoring. It's important to remember that these are the **designed** or **intended** objectives for the trail and may not reflect existing conditions.

Trail type—The trail type is identified on the TMO form. Remember there is only one trail type per trail. Trail types were explained in chapter 4, "Trail Fundamentals."

A trail managed for ATV use is typically a standard/terra trail. If this route also is managed for snowmobile use, it also would be inventoried as a snow trail. The standard/terra trail and the snow trail each would have its own trail name, number, and corresponding TMO. For example, TMOs would be developed both for Wolverine Trail 476 and Wolverine Snow Trail 476S. In general, the OHV trail manager only has management responsibility for summer use of Wolverine Trail 476, but would want to coordinate maintenance and other management actions with the snow trail manager. The OHV trail manager would pay particular attention to sign location and installation height, clearing width and height, and any major tread modifications that might affect winter use.

Trail class—Identify the trail class. The five Forest Service trail classes were discussed in chapter 4, "Trail Fundamentals." Appendix C is the "Forest Service Trail Class Matrix." If the prescribed trail class changes along the trail, it's important to create a separate TMO for each trail section.

ROS/WROS class—Choose the applicable recreation opportunity spectrum (ROS) or wilderness recreation opportunity spectrum (WROS). These management categories are used by the Forest Service and BLM.

Designed use—Identify the designed use. Only one designed use should be identified for each trail or trail section. The designed use determines the design, construction, and maintenance specifications for the trail. It is selected from the actively managed uses identified for the trail. The concepts of designed use and managed use were explained in chapter 4, "Trail Fundamentals." Again, if the designed use changes along the trail, create a separate TMO for each trail section.

Design parameters—Identify the trail design parameters. Refer to the explanation of design parameters in chapter 4, "Trail Fundamentals." The TMO should identify **specific** values for the individual parameters, such as tread width, clearing width, and target grade. The design parameters identified for individual trails should take into consideration trail-specific site conditions and the mix of managed uses and expected use levels.

Target frequency—Identify the recommended or target frequency for routine maintenance tasks. The target frequency is the recommended number of times the maintenance task would be performed in a year. For example, routine brushing once a year is expressed as 1, twice a year as 2, every other year as 0.5, and every fifth year as 0.2.

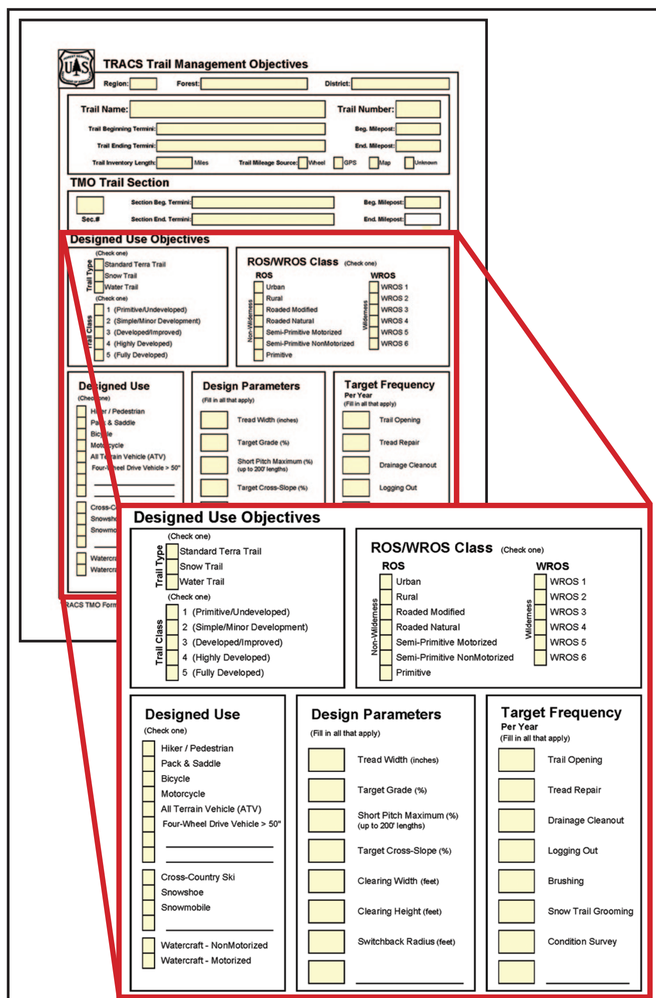


Figure 8–2—Part 2 of the TRACS TMO form.

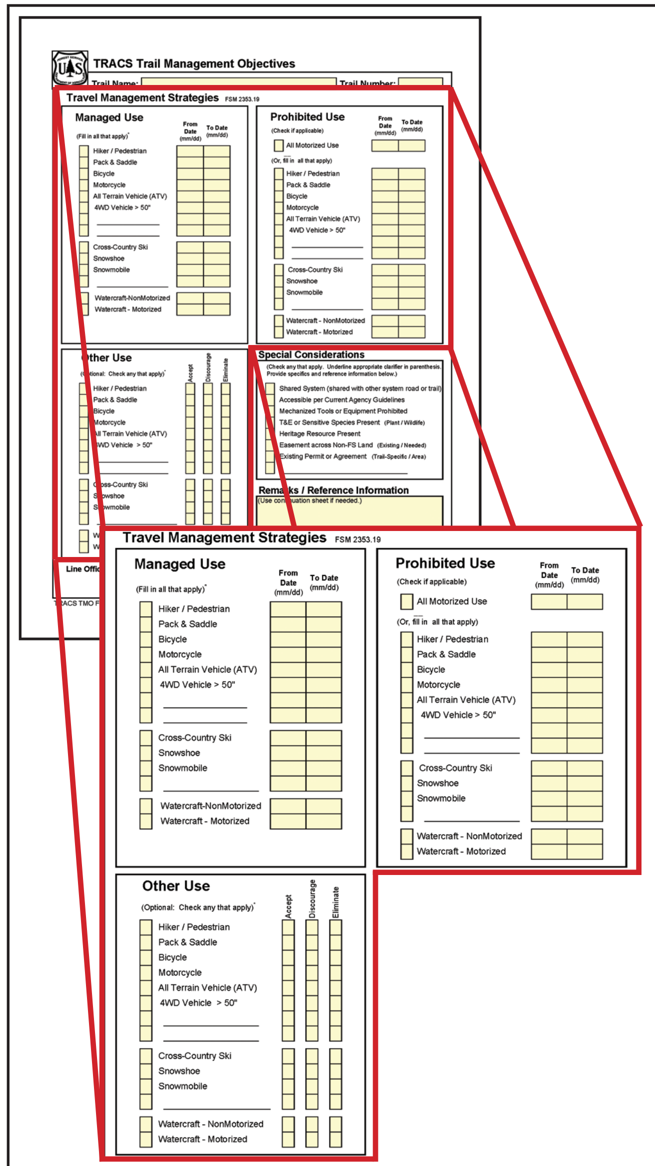
Part 3—Travel Management Strategies

The third part (figure 8–3) of the TMO form identifies travel management strategies. The travel management strategies identify the overall management philosophy or long-term management intentions for a trail and should be subject to agency requirements for planning, public participation, and decisionmaking. Identifying these strategies helps the agency and OHV trail manager address the needs of conflicting uses and set maintenance priorities.

Managed uses—Document the actively managed uses identified for the trail and the corresponding managed seasons of use. Refer to the discussion of managed use in chapter 4, "Trail Fundamentals." The managed use, along with the designed use, helps determine the design, construction, and maintenance specifications for the trail. Managed use also plays a role when managers identify and communicate travel management strategies, including prohibited and allowed uses.

Prohibited uses—Identify the prohibited uses. These prohibitions should be specific, by use and by season of restriction. When identifying a prohibited use, cite the specific regulation, rule, or agency order prohibiting the use in the Remarks/Reference Information section of the TMO form. Closures can be year round. For instance a TMO may indicate that mountain bike use is prohibited on a trail through a designated wilderness. Some closures are seasonal. For instance a trail actively managed for ATVs may be closed between March 1 and May 1 because of spring breakup.

Other uses—Identify other use strategies (optional).


TRACS Trail Management Objectives

Travel Management Strategies FSM 2353.19

Managed Use (Fill in all that apply) — From Date (mm/dd) — To Date (mm/dd)
Hiker / Pedestrian
Pack & Saddle
Bicycle
Motorcycle
All Terrain Vehicle (ATV)
4WD Vehicle > 50"
Cross-Country Ski
Snowshoe
Snowmobile
Watercraft-NonMotorized
Watercraft - Motorized

Prohibited Use (Check if applicable) — From Date (mm/dd) — To Date (mm/dd)
All Motorized Use
(Or, fill in all that apply)
Hiker / Pedestrian
Pack & Saddle
Bicycle
Motorcycle
All Terrain Vehicle (ATV)
4WD Vehicle > 50"
Cross-Country Ski
Snowshoe
Snowmobile
Watercraft - NonMotorized
Watercraft - Motorized

Other Use (Optional: Check any that apply) — Accept — Discourage — Eliminate
Hiker / Pedestrian
Pack & Saddle
Bicycle
Motorcycle
All Terrain Vehicle (ATV)
4WD Vehicle > 50"
Cross-Country Ski
Snowshoe
Snowmobile
Watercraft - NonMotorized
Watercraft - Motorized

Special Considerations
Shared System (shared with other system road or trail)
Accessible per Current Agency Guidelines
Mechanized Tools or Equipment Prohibited
T&E or Sensitive Species Present (Plant / Wildlife)
Heritage Resource Present
Easement across Non-FS Land (Existing / Needed)
Existing Permit or Agreement (Trail-Specific / Area)

Remarks / Reference Information

Figure 8–3—Part 3 of the TRACS TMO form.

Part 4—Special Considerations and Remarks/ Reference Information

Part 4 of the TRACS TMO (figure 8–4) includes two blocks for special considerations and remarks/reference information.

Special considerations may affect management or maintenance of the trail. These considerations may be accessibility status, the presence of sensitive species or archeological sites, easement restrictions, or other considerations. If present, these considerations and corresponding management direction or reference information should be included in the Remarks/Reference Information section. If information refers to a certain trail section, include mileposts or other location coordinates.

The TRACS TMO form provides space to add information or clarifications or to cite agency decisions. When relevant information has been presented in previous sections of the form, it helps to add a footnote that will direct readers to the Remarks/Reference Information section.

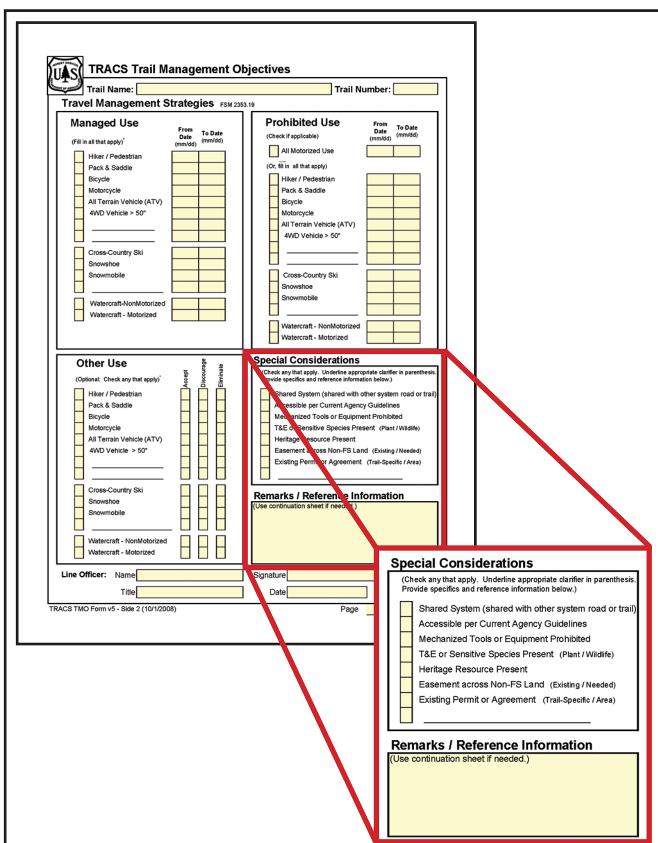


Figure 8–4—Part 4 of the TRACS TMO form.

Part 5—Line Officer Approval

The agency line officer's signature (figure 8–5) shows that the TMO accurately reflects the management intent for the trail and provides clear management direction to agency and trail management employees. If and when management direction changes for a trail, the TMO should be updated. Situations that may trigger a change in management direction are addressed later in this chapter. The TMO form, instructions, and additional information are available on the Forest Service's internal computer network at http://fsweb .wo.fs.fed.us/rhwr/ibsc/tr-tracs.shtml.

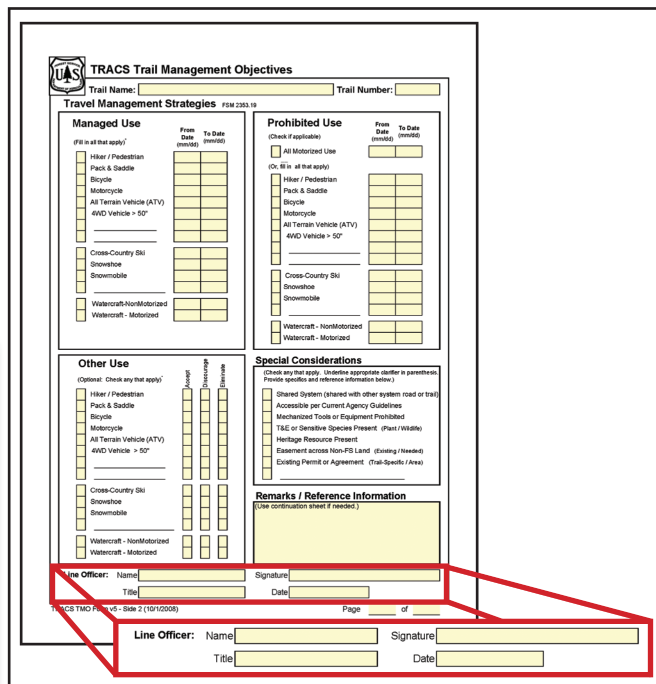


Figure 8–5—Part 5 of the TRACS TMO form.

Developing Trail Management Objectives

The TMO is a critical management tool for planned and existing trails. Few trail management activities should be conducted without one. If a TMO does not exist, one should be developed as soon as possible, ideally before major resource investments are made on a trail. Developing a TMO requires the services of trail management professionals, as well as the involvement of interested trail partners and users. The TMO defines both the **starting** and the **ending** points of trail management. It documents the overall management goals for the trail and provides direction throughout the management process. The TMO is the essential reference for long-term assessment and monitoring of trail conditions, performance, and maintenance needs.

The process for developing a TMO is basically the same for new and existing trails. Existing trails require additional evaluation on the ground, which may affect management objectives. In some cases a trail manager may not be sure what the appropriate trail management objectives should be for an existing trail. This is most common with orphan trails—trails within administrative areas that do not have an active trail management program or areas with a history of unregulated OHV use.

To develop a TMO for an existing trail, information should be collected on its use characteristics, trail conditions, and trail sustainability. This information will help managers identify several key components of a TMO: the appropriate managed uses, the trail classes, and the design parameters.

Defining Trail Use Characteristics

Define trail use characteristics using data collected on:

- Existing use types (size, width, weight, and so forth)
- Approximate volume of use
- Relative intensity of use (concentration)
- Seasons of use
- User needs, preferences, satisfaction, and behavior
- Use trends

"Element 1—Preliminary Status Assessment" is a good place to start gathering data. Creating a list of existing uses can help trail managers make decisions about allowed uses, prohibited uses, managed uses, and designed uses. Before identifying allowed uses, managed uses, and designed uses in a TMO, it's important to understand the physical characteristics of the trail, the effect past and existing use is having on trail conditions, and the sustainability of the trail alignment and construction.

Assessing Trail Conditions

Collect basic information on the physical character of the trail and its condition. Basic information includes:

- Tread grade (typical trail grade in percent or a defined range of grades)
- Tread width (width of the area affected by traffic)
- Tread surface character (roughness, obstacles, hazards, etc.)
- Condition category (good, fair, degraded)

Trail grade is normally expressed as a percentage, calculated by dividing the elevation change of a trail segment by its length and multiplying the result by 100. Field data on current trail grade, width, and surface character can be used to evaluate TMO trail class assignments for potential or identified managed uses.

Ideally, managers would assign trails to a trail class that best reflects existing management direction for the trail. This approach, which is required by some agencies, applies when agency plans or directives have been established for management areas, trail networks, or specific trails. Condition assessment data would help managers determine whether the trail meets the specifications for the prescribed trail class or how much modification might be required to meet them. If those modifications are too costly, a pragmatic approach may be to modify the TMO by changing the trail class assignment to one that is closer to the current physical characteristics. In either case, knowing the trail grade, width, and surface character will help managers determine the range of possible managed, allowed, and designed uses and trail class assignments.

Before the final use type and trail class assignments are made, the effect of existing uses on trail conditions should be considered. If a trail is generally in good condition, existing use types and levels may be appropriate with routine maintenance. Trails that are generally in poor or degraded condition may have inappropriate uses, poor design, poor quality construction, or inadequate maintenance. Determining exactly what has contributed to poor or degraded conditions requires further evaluation of trail sustainability.

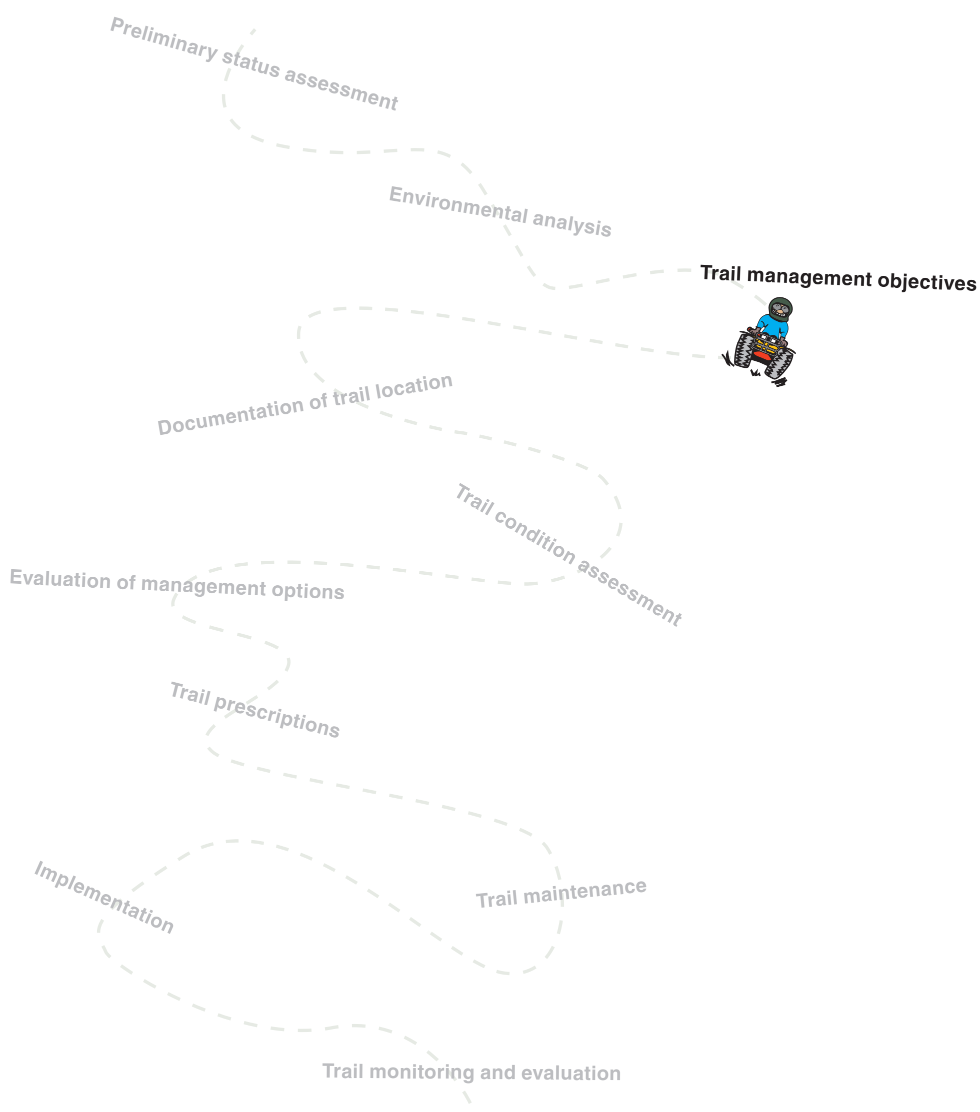
Evaluating Trail Sustainability

Two methods can be used to evaluate trail sustainability. The first method is an initial evaluation using a topographic map (topo map) with an annotated trail alignment (discussed in "Element 4—Documentation of Trail Location"). The second method is a more detailed evaluation based on trail condition and sustainability (discussed in "Element 6—Evaluation of Management Options"). Evaluations of trail sustainability help guide management decisions affecting use characteristics, design parameters, maintenance frequency, necessary capital improvements, or any type of mitigation, such as reroutes, rehabilitation, or trail closure.

If an evaluation shows that existing trail use matches agency goals and a trail is in good condition with a sustainable trail design and layout, developing a TMO should be easy and management should be straightforward. If an evaluation uncovers problems, the process will be more difficult. Correcting the problems may require modifying trail use characteristics, increasing maintenance, or making major investments in a trail—changes that may be costly or unpopular.

Having a thorough understanding of trail use, condition, and sustainability provides a solid base for TMO development and future trail management.

The "TMO Development Input" form in appendix E can help trail managers as they collect data on trail use, condition, and sustainability. The completed form also can help them evaluate data during TMO development and when managing the trail.



Chapter 9: Element 4—Documentation of Trail Location

An accurate map of the trail location provides information that helps answer four important questions:

- Where is the trail, **exactly?**
- Whose land does the trail cross and what features are located nearby?
- What is the character of the physical environment surrounding the trail?
- Does the trail have sustainable design and layout?

Locating the Trail

Since knowing what to manage depends on knowing where to manage, it's important to have an accurate trail location map. Often trail location maps are out of date, incomplete, inaccurate, or of poor quality. Over time, the trail character may change and new spur trails, cutoff trails, or braided trail segments may have developed. Trail maps should be updated regularly.

Global positioning systems (GPS) can help managers map the trail centerline. Figure 9–1 shows a variety of GPS instruments that are used for trail mapping. Determining a trail centerline is relatively quick and simple with a GPS receiver (figure 9–2). The specific method used depends on the operator's training and skill, available equipment, and the accuracy required by the sponsoring agency.

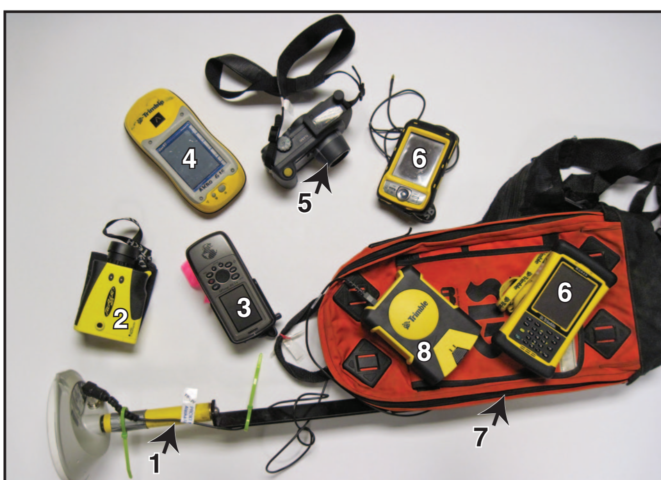


Figure 9–1—Examples of GPS units and support hardware used for trail mapping work. Clockwise from bottom left: external GPS antenna (1), laser rangefinder (2), recreation-grade GPS receiver (3), mapping grade GPS receiver (4), digital camera with integrated GPS and compass (5), data loggers (6), field GPS backpack (7), and mapping-grade GPS receiver (8).

Figure 9–2—Two NPS staff members map a trail centerline with mapping-grade GPS receivers on Kodiak Island. They are collecting a center point to document a trail intersection.

Trail Location Method 1—Recreation-Grade GPS Receivers

Recreation-grade GPS receivers are best used for general reference maps on lands managed by a single land manager. Figure 9–3 shows a map made using data collected with the recreation-grade GPS receivers that are widely available.

This method does not provide highly accurate data, but may be adequate for some management applications. A track log of the centerline of the trail and individual waypoints are obtained while traversing the alignment. The track log provides a reasonably accurate centerline location and the waypoints provide coordinates for points of interest along the trail alignment. The data can be displayed using simple mapping software or downloaded as a shapefile for input into a geographic information system (GIS). Other software allows the geographic data collected with a GPS receiver to be linked with digital photos.

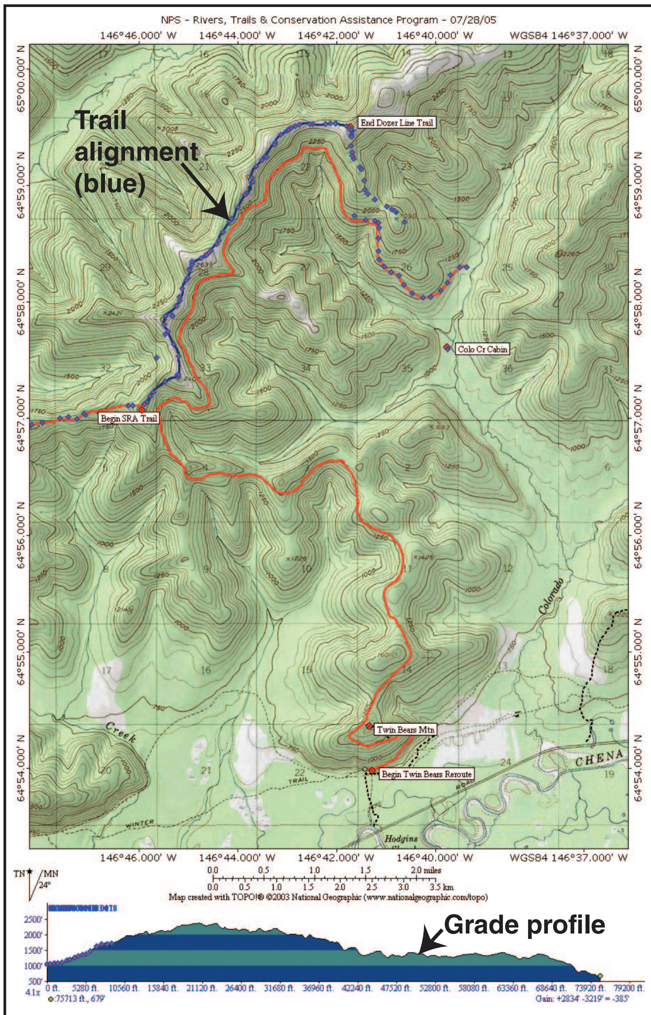


Figure 9–3—Two trail alignments displayed on a topographic map base. This map product was generated from a recreation-grade GPS receiver and displayed on a shaded relief topographic map to enhance the terrain features. Note the grade profile of one of the trails displayed across the bottom of the image. Take a closer look at the (blue) trail alignment at the top of the image and see if you can identify any problems with its alignment. —*Base map and profile produced using TOPO! ©2008 National Geographic.*

into a GIS. Mapping-grade GPS receivers are considerably more expensive than recreation-grade receivers and require more training for mapping and data processing. Typically, GPS data collection using mapping-grade receivers is limited to agency-supported mapping efforts. Table 9–1 compares recreational- and mapping-grade GPS receivers.

Table 9–1—Comparison of recreation-grade and mapping-grade GPS receivers. Recreation-grade GPS receivers usually cost $100 to $300. Mapping-grade GPS receivers usually cost $3,000 to $5,000.

Features	Recreation-grade GPS receivers	Mapping-grade GPS receivers
Accuracy	Generally accurate within 10 to 15 meters or less	Generally accurate within 3 to 5 meters Most units allow for real-time differential correction for improved accuracy
Post field correction	Generally not an option	Integrated component
Accuracy under canopy	Fair to good	Good to very good
GIS integration	Possible with supplemental software	Integrated within the system
Attribute descriptions	Limited to labeled track logs and waypoints	Extremely flexible and detailed

Trail Location Method 2—Mapping-Grade GPS Receivers

Mapping-grade GPS receivers are versatile and quite accurate. They may include an internal data dictionary, which allows them to record additional information regarding the trail, such as descriptive labels for point data and attribute descriptions for trail segments. This capability is described in greater detail under “Element 5—Trail Condition Assessment.” The software packages of mapping-grade GPS receivers are configured to transfer data directly

Trail Location Method 3—Survey-Grade Engineering Instruments

A third method of GPS centerline mapping uses survey-grade engineering instruments. This method provides the most accurate data but requires highly sophisticated equipment and professionally trained operators. Typically, this type of work is performed by specialized agency crews or professional land surveyors. Survey-grade accuracy may be required when locating rights-of-way or dealing with complex land status issues.

GPS Accuracy

Most manufacturers test their receivers in open canopies and report the results as expected accuracy. This accuracy cannot be achieved when the GPS receiver is used under a forest canopy. The Forest Service's Missoula Technology and Development Center (MTDC) tests GPS receivers on special courses and posts the tested accuracies in a spreadsheet that is available at http://www.fs.fed.us/ database/gps. MTDC also tests GPS receivers for their ease-of-use, ruggedness, and other characteristics that are important for field users (Trent and Karsky 2008, http://www.fs.fed.us/t-d/pubs/htmlpubs/htm08712807/).

Regardless of the type of GPS receiver that is used, GPS centerline mapping can be conducted relatively quickly. The trail manager or agency usually determines the method used for a specific trail mapping project. Figures 9–4 and 9–5 show some innovative methods of field data collection. All field operations should be conducted safely, after development of a job hazard analysis (see "Element 9—Implementation").

Figure 9–4—GPS centerline mapping of OHV trails may be conducted in the winter by snowmobile. This technique can provide for very rapid data collection in some areas.

Figure 9–5—This handlebar-mounted GPS unit was used for centerline data collection on a pioneered OHV trail. The use of a mountain bike allowed for quick data collection with little additional environmental impact.

While mapping, it can be beneficial to establish temporary or permanent milepost markers or record distance measurements to specific features, such as stream crossings, trail junctions, or other prominent trail features. These distance measurements can be helpful during condition assessments or construction and maintenance operations.

Distance measurements can be taken with measuring wheels, GPS receivers, or odometers. Measuring wheels provide the most precise data. Temporary distance measurement stations can be established using survey flagging, lath, posts, or plastic or aluminum tags attached to trees or shrubs. GPS coordinates may be recorded at milepost locations, if desired.

Centerline mapping may be a good time to collect basic physiographical and biological information along the alignment. This information can include trail grade, sideslope, soil type, and brush and timber character. These are productivity factors in the Forest Service TRACS trail assessment and condition survey method discussed in "Element 7—Trail Prescriptions."

Trail Location Method 4—Aerial Photos

High-resolution aerial photography or satellite imagery can also be used for trail location. This may be an attractive option if it's not possible to traverse the trail, GPS data collection is considered too complicated or costly, or a large-scale mapping project is being conducted. The Forest Service and BLM typically have quality aerial photography for lands they manage. In rural America, the U.S. Department of Agriculture, Natural Resources Conservation Service, and State or local forestry offices often have aerial photography coverage. The National Aerial Photo Program has standardized, cloud-free images of all areas of the United States, taken over 5- to 7-year cycles (http://edc.usgs.gov/products/aerial/napp.php). When locating and transferring trail location data from aerial photos, determine whether the imagery has been rectified—that is, geometrically corrected to ground features. If not, the location data may not be accurate enough to match up with topographic maps or GIS data.

One source of satellite imagery is Google Earth. In many areas, Google Earth has posted high-resolution rectified imagery that is detailed enough to recognize and delineate trail alignments. Figure 9–6 shows a Google Earth image with a proposed trail alignment. Often Google Earth images are good enough to use as a project base map. If you use Google Earth images for a base map, the images should be purchased. They usually are available at a reasonable cost.

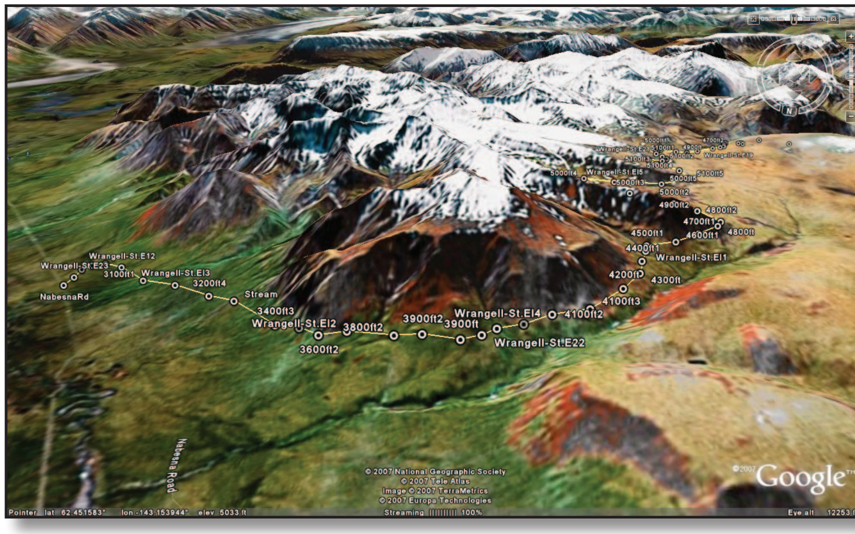


Figure 9–6—A Google Earth image of a trail alignment. —*©2007 Google, ©2007 National Geographic Society, ©2007 Tele Atlas, Image ©TerraMetrics, ©2007 Europa Technologies.*

Identifying the Lands or Features That the Trail Crosses

With accurate centerline data trail managers can determine whose land a trail crosses. The **ability** to manage a trail depends on having the **authority** to manage it. Land status questions are best answered by displaying the trail alignment over a Federal, State, or local land status plat map.

In figure 9–7 a trail alignment crosses five different land ownership types. That information would be valuable to a trail manager because it indicates that management could be complicated. The trail manager should ensure that rights-of-way have been reserved on all private parcels before planning any major trail improvements.

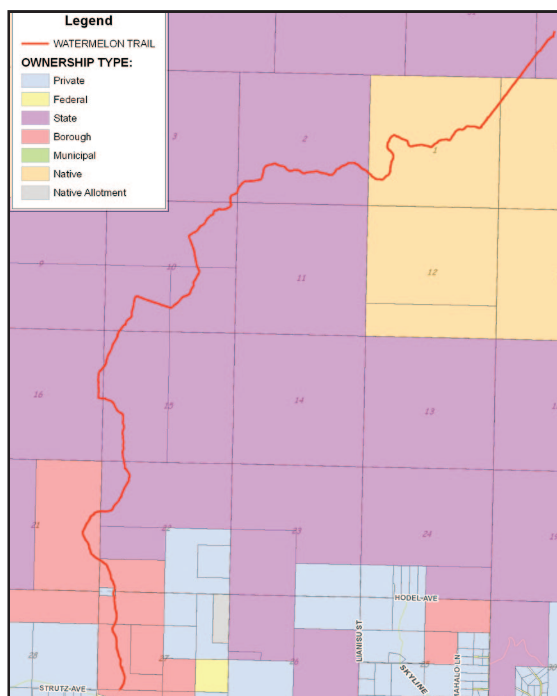


Figure 9–7—A trail alignment projected over a land status plat.

Identifying the Character of the Physical Environment Surrounding the Trail

Accurate trail alignments also help managers evaluate the general physical environment beneath and surrounding the trail. A GIS can display the trail alignment along with any combination of other resource attributes (figure 9–8).

The resource data of particular importance for trail management include:

- **Topography—**Slope, elevation, aspect, watershed boundaries, and relationship to nearby terrain features such as lakes, cliffs, or floodplains
- **Hydrology—**Drainage patterns, stream character, and locations of wetlands, rivers, lakes, and streams
- **Fisheries—**Fish habitat at stream crossings
- **Soils—**Tread surface texture and subsurface drainage
- **Administrative status—**Land administrative status, wilderness boundaries, and Federal, State, and local land management designations
- **Transportation networks—**Location of roads, parking areas, other trails, and nearby facilities
- **Infrastructure—**Location of power lines, buildings, and utility systems
- **Vegetation—**Data on ground cover, brush, and canopy; location of wetlands, sensitive plant habitats, and invasive species
- **Wildlife—**Critical habitats, nesting sites, calving grounds, den sites, travel, or migration routes
- **Cultural Resources—**Sensitive historic/archeological resources to protect, historic/archeological features to interpret

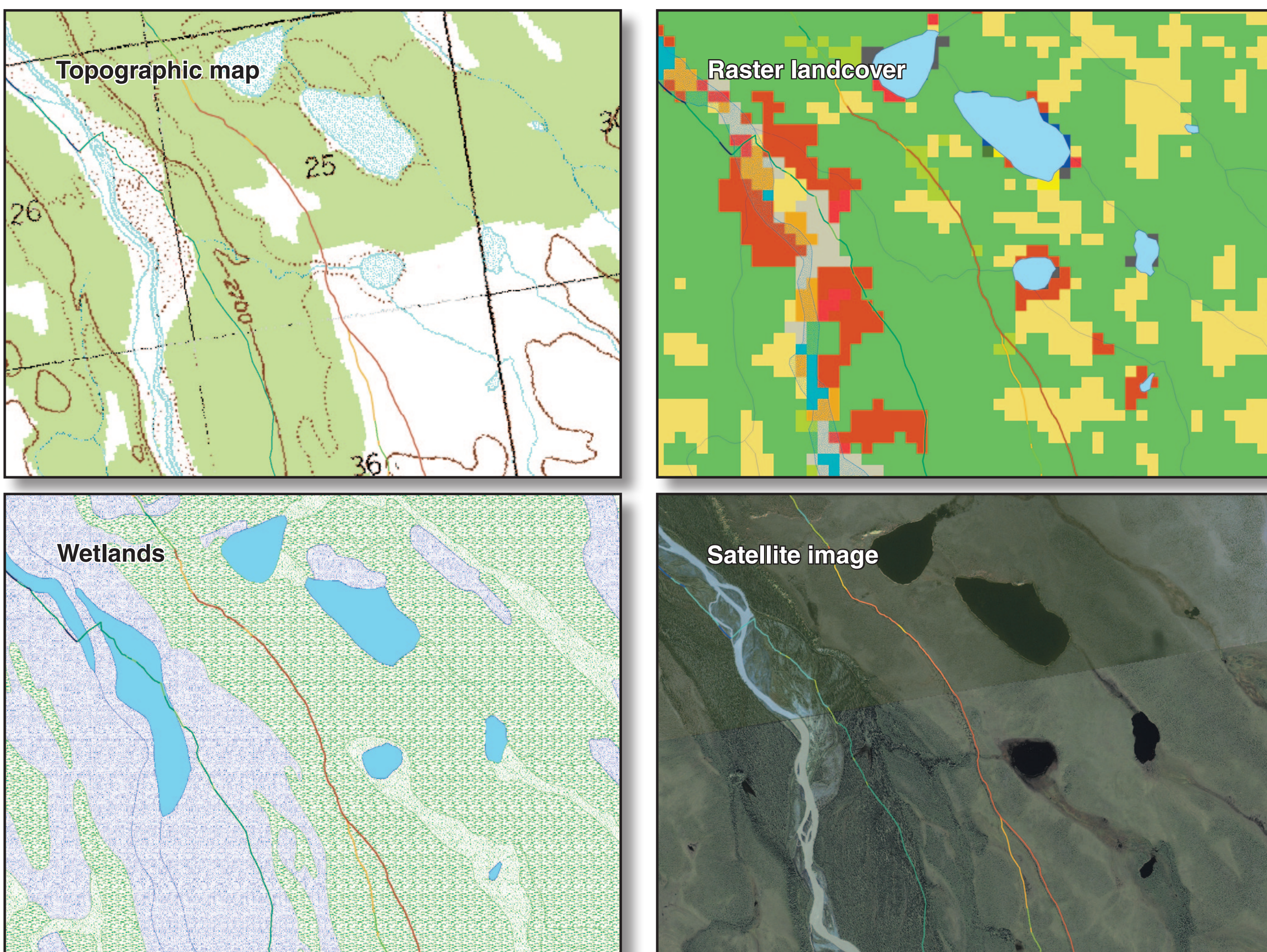


Figure 9–8—A series of GIS data layer displays for a trail alignment.

Assessing Sustainable Trail Design and Layout

When projected onto a topographic map, the relationships between the trail alignment and the terrain can be examined in detail. Pay close attention to the way the trail runs along or across the terrain and the way the trail crosses drainages. Examining the trail alignment as it crosses map contour lines helps determine whether the trail generally meets two of the six sustainable trail design guidelines: contour and grade. To meet the first guideline, the trail alignment must generally run along contour lines or cross them at a shallow angle (figure 9–9). (See controlled grade in chapter 2, "Sustainable Trail Design Guidelines.") To meet the second guideline, the trail alignment generally should not exceed an average grade of 10 percent.

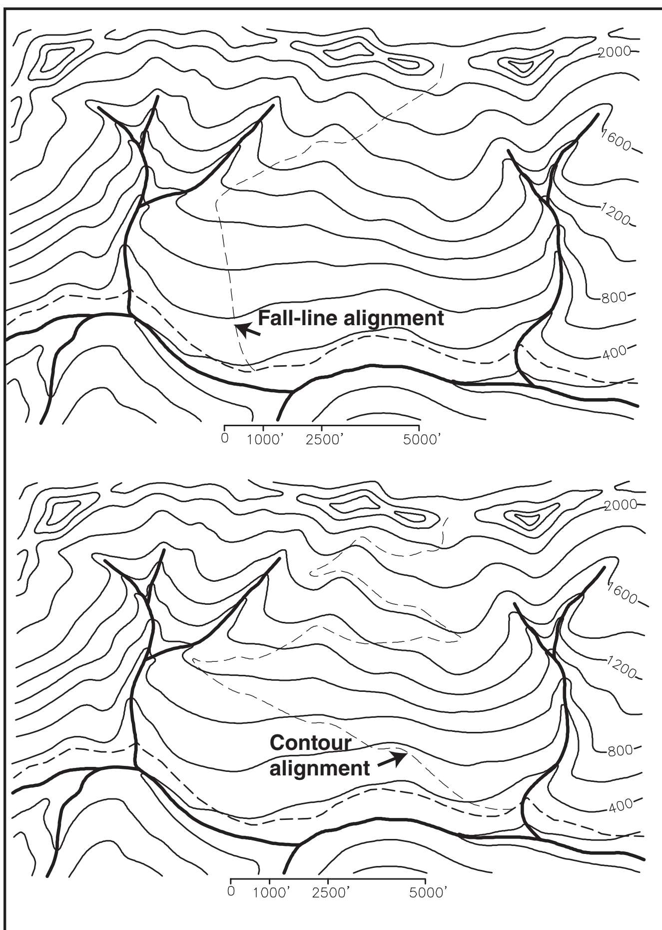


Figure 9–9—Two trail alignments plotted over a topographic map base. In the top image, the trail runs directly up and down the slope, an example of a fall-line alignment. Fall-line alignments are inherently unsustainable. In the bottom image, the trail crosses the contour lines at a shallow angle. This meets the standards for a sustainable contour curvilinear alignment.

Trail grade, calculated as rise over run multiplied by 100, is expressed as a percentage.

On a topographic map, the grade is calculated by measuring elevation change (rise) and the distance between two points (run). The two points should be selected to delineate trail segments where the grade is relatively uniform. Figure 9–10 displays a trail alignment climbing a slope before contouring across the head of a drainage. Note the four waypoints, A through D, along the alignment. These points will be used to help calculate the average trail grade (table 9–2) for the three trail segments they establish.

In this case, the average grade is less than 10 percent for all three trail segments. Each segment meets the sustainable trail design guideline for controlled grade. Contrast the alignment in figure 9–10 with the fall-line alignment shown at the top of figure 9–9, which has an average trail grade of 15.3 percent (1,800-foot elevation difference divided by 11,800 feet trail length multiplied by 100), exceeding the guideline for controlled grade.

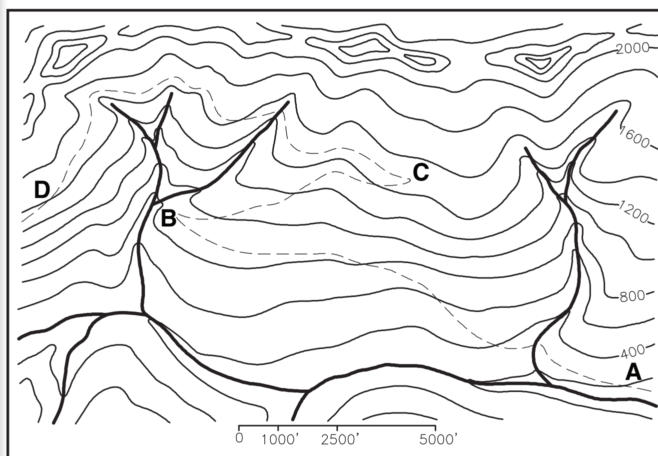


Figure 9–10—A trail alignment with reference points A through D, used in the trail grade calculation example.

Measuring Grade

Percent grade equals the rise (elevation change) divided by the run (horizontal distance) multiplied by 100.

A trail segment 100 feet long with a 10-foot rise would be a 10-percent grade. A 10-foot rise over a 10-foot run is a 100-percent grade.

Elevation change is always expressed as a positive number. In trail management, grades may be expressed as +10 percent for an ascending grade and -10 percent for a descending grade relative to the direction of travel. Percent grade can be expressed as an equation:

$$\frac{Rise}{Run} \text{ x } 100 \text{ percent}$$

A clinometer, sometimes called a clino by trail workers, is a simple, useful, field instrument for measuring grades. Most clinometers have two scales, one indicating percent slope, the other showing degrees (figure 9–11). Percent slope, the relationship between rise or drop over a horizontal distance, is the most commonly used measurement for trail work. Percent readings are found on the right-hand side of the clinometer's scale, degree readings on the left-hand side. Do not confuse percent and degree readings. It is easy to do! **If you read RIGHT, you will always be right.**

Still confused? "Lightly on the Land" (Birkby and the Student Conservation Association 2005) includes an entire chapter on "Measuring Distance, Grades, and Heights" (chapter 7).

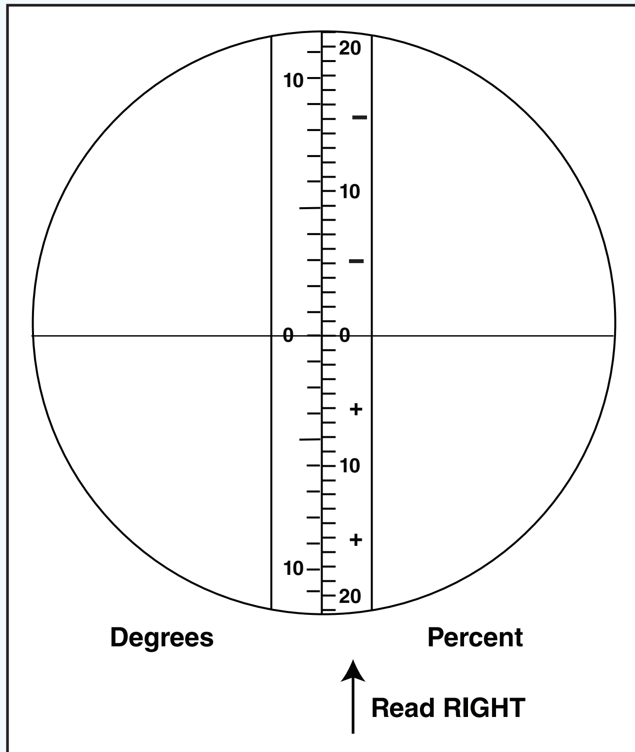


Figure 9–11—The view inside a clinometer, degrees on the left, percent on the right.

—Adapted for OHV trails from the "Trail Construction and Maintenance Notebook" (Hesselbarth and others 2007).

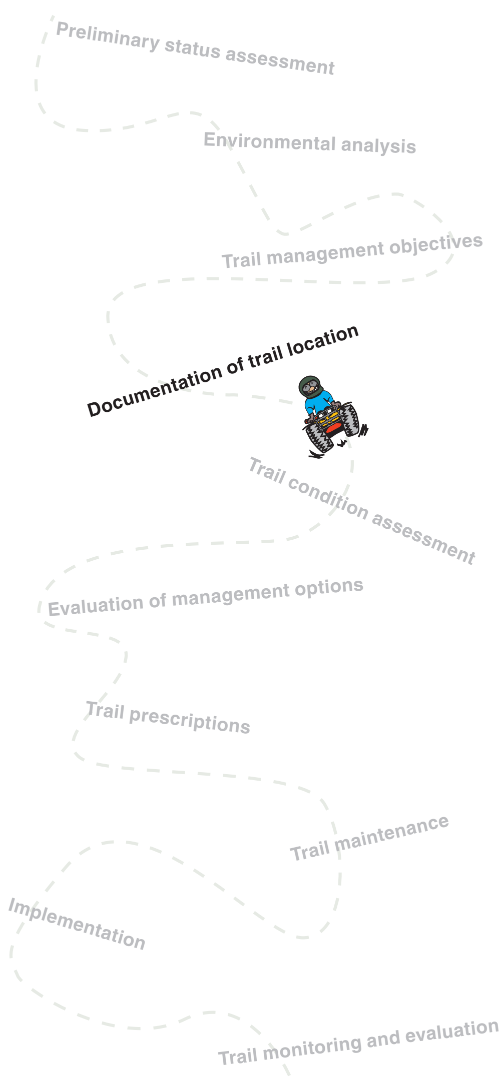
Table 9–2—An example showing how to calculate average trail grade.

Waypoint	**Elevation** (feet)	**Rise between waypoints** (feet)	**Run between waypoints** (feet)	**Rise ÷ Run x 100**	**Average grade** (percent)
A	300				
B	850	Between A and B = 550	Between A and B = 12,500	550 ÷ 12,500 × 100	6.87
C	1,450	Between B and C = 600	Between B and C = 6,250	600 ÷ 6,250 × 100	9.60
D	1,600	Between C and D = 150	Between C and D = 13,750	150 ÷ 13,750 × 100	1.10

In addition to the specific sustainable trail design guidelines, the following three sustainable layout considerations can be evaluated by examining the topographic trail map display. They include:

- **Landscape position—**The trail's location relative to the terrain helps determine the long-term trail sustainability. In general, the ideal location for a trail is on the upper third of sideslopes because these areas tend to have the fewest surface water issues. Certain terrain features should be avoided: ridgelines, toe slopes, and aspect (depending on climate).
- **Areas with surface slope less than 3 percent—**Flat areas are the bane of trail builders because of the problems of tread entrenchment and poor surface drainage. Flat areas should be avoided as much as possible to reduce long-term maintenance.
- **Drainage crossings—**Drainage crossings often require expensive structures, such as improved fords, culverts, or bridges. Placing trails high on sideslopes may eliminate crossings or reduce their size and number. Trail alignments should also dip in and out of all sideslope drainages (even minor drainages) to prevent stream capture, where water is diverted and runs down the trail alignment.

With an accurate trail alignment displayed on a topographic map, a trail manager can quickly evaluate the sustainable design and layout of a trail (figure 9–12).



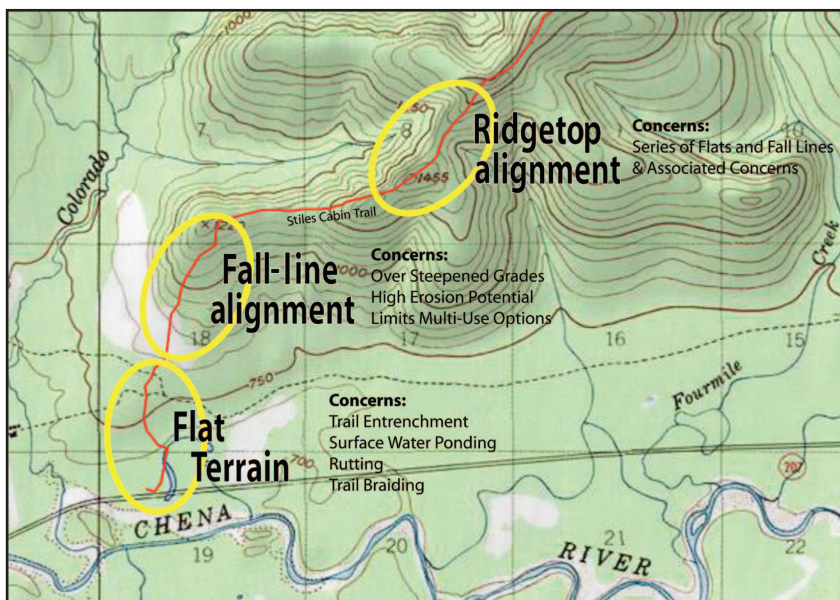


Figure 9–12—A trail alignment on a topographic map base displaying common alignment problems. —*Base map produced using TOPO! ©2008 National Geographic.*

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Chapter 10: Element 5—Trail Condition Assessment

A trail condition assessment is a detailed on-the-ground inventory of the character and physical condition of the trail tread and associated trail structures. This assessment is based on parameters such as trail grade, width, surface type, state of repair, and similar characteristics, allowing a trail to be divided into short segments. Trail structures or features like bridges and retaining walls are also identified and described. A condition assessment documents trail conditions at the time the assessment was conducted. It records conditions along every foot of the trail—not just problem sites—to provide baseline data that can be used to assess condition trends. A baseline condition assessment provides a key reference for general trail planning efforts, TMO development, trail evaluation, and long-term maintenance and monitoring.

Trail condition assessments can be conducted using a variety of systems. The Forest Service has a standardized system called TRACS that is used to collect baseline inventory, conduct condition assessments, and develop prescriptions for needed maintenance or improvements. The TRACS system is discussed in "Element 7—Trail Prescriptions."

Figure 10–1—A clinometer is used to measure trail grade. This small hand-held instrument allows trail grade or terrain sideslope to be measured quickly and easily.

Inventory Techniques

Traditionally, trail condition assessments were conducted using a clinometer (figure 10–1) or Abney hand level, measuring wheel or 100-foot tape, field notebook, and a compass. Several assessment techniques still rely on these tried and true methods.

The advent of GPS, GIS, and portable field computers provides opportunities to increase field mapping capabilities and efficiency. These technologies have proven especially valuable in Alaska, where thousands of miles of poorly developed OHV trails have not been inventoried. In Alaska, GPS receivers have been used to collect consistent data rapidly while crossing large, remote landscapes (figure 10–2). That data can be integrated efficiently into a GIS.

Figure 10–2—OHV trail managers in Alaska often face challenges mapping trails in remote areas. Similar conditions are found in other parts of the country.

Three general types of data are common to both manual and instrument-assisted trail condition assessments:

Point data—Trail structures and trail or natural features that are best represented by a single point. Examples include a sign, the center point of a trail junction, the bottom of a grade dip, or the location of a survey marker (figure 10–3).

Figure 10–3—A park bench located along a trail alignment is documented as a GPS point feature.

The full list of specific features to be mapped will vary. The data collected during a trail condition assessment includes **attribute** information about each **feature** and **values** associated with each attribute.

Relationship Between Features, Attributes, and Values

Features (types of points, lines, or areas)
Attributes (information about the features)
Values (values of the attributes)

An example of point data:
HAZARD (feature)
TYPE (attribute)
Major washout (value)

An example of line data:
TRAILWAY (feature)
TRACKTYPE (attribute)
Main (value)

Line data—Linear features are best represented by a single or segmented line. Examples include the trail alignment itself, roads, fences, power lines, or administrative or property boundaries.

Area data—Features that occupy large two-dimensional areas. Area features can be angular or irregularly shaped polygons. Examples include trailhead parking lots, braided trail areas, borrow pits, or the footprint of a large structure (figure 10–4).

Figure 10–4—GPS mapping of a deck at a scenic overlook. The deck could be mapped as a point feature to simply denote its location, or as an area feature to document its footprint. Two surveyors are collecting data. The second instrument provides a backup dataset.

Data terms used to define features and attributes are capitalized (except in figures 10–5 and 10–11). See Appendix F, “Definitions of Terms for the Alaska NPS OHV Condition Assessment Data Dictionary” and “Alaska NPS OHV Trail Prescription GPS Data Dictionary,” for definitions of data terms.

One way to organize trail features, attributes, and values is to create a data dictionary. Data dictionaries are organized outlines of all the point, line, and area data that might be encountered in the field. Data dictionaries are flexible, so they can be customized to fit a specific need. In general, it is better to be inclusive when preparing a data dictionary, rather than to leave out details. The level of detail can be managed by using drop-down menus, which help ensure that terminology is used consistently when identifying mapped features.

The “Alaska NPS OHV Condition Assessment Data Dictionary” (appendix F) has been developed and refined over 4 years of extensive OHV trail condition assessment mapping by the NPS Alaska Regional Office. This dictionary has a fairly complete list of trail tread condition features and associated attributes, but the list of trail structures is incomplete. This combination has worked in Alaska where most trails are poorly developed and have few structural improvements.

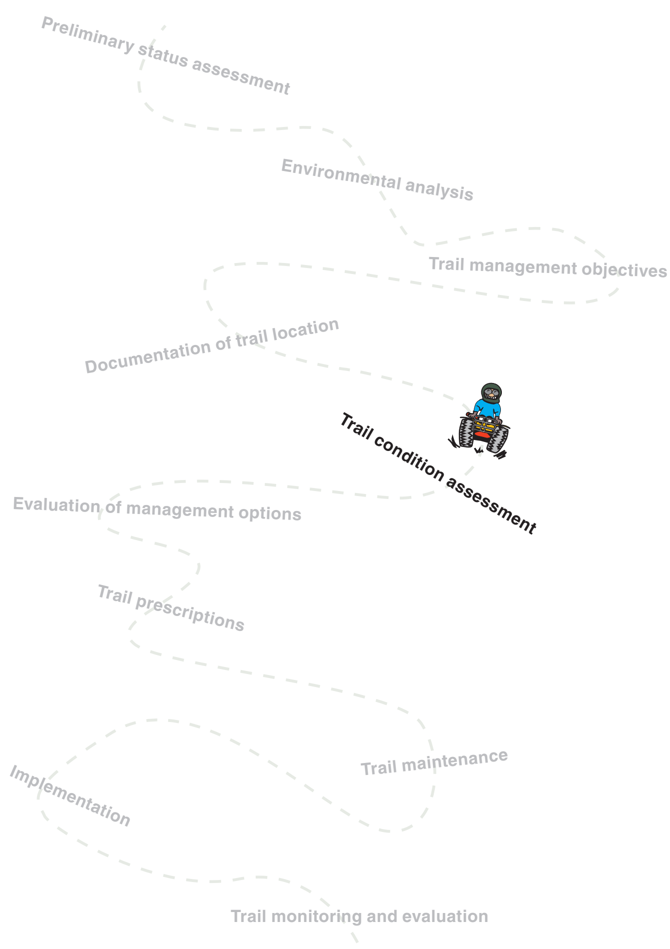
As in any dictionary, a definition of the terms used to describe line, point, and area features, attributes, and values helps ensure consistency in data identification and application. Appendix F includes the “Definition of Terms for the Alaska NPS OHV Condition Assessment Data Dictionary.”

The Forest Service TRACS system user guide also has a data dictionary (available on the Forest Service’s internal network at http://fsweb.wo.fs.fed.us/rhwr/ibsc/tr-data-dictionary.shtml) with an expansive list of structures found on well-developed trails.

Figure 10–5 displays examples of the line feature TRAILWAY with its associated attributes and values for four representative sites based on the “Alaska NPS OHV Condition Assessment Data Dictionary.”

Federal Trail Data Standards

In 2009, Federal agencies agreed to a set of Federal Trail Data Standards. These standards were developed to provide consistency between agencies for reporting and map production. The standards include a set of defined terms, some of which are used in data dictionaries. Trail managers are encouraged to adopt and use these terms, as defined, when developing data dictionaries or when mapping trails. Information about these standards is available at http://www.nps.gov/gis/trails/.



Reeve Field Trail, Wrangell-St. Elias National Park (NPS)

Attribute	Value
Track type	Main
Track	Multibraid 5 to 10
Impact width	18 to 24 feet
Trail grade	0 to 3 percent
Tread geometry	Entrenched
Trail surface character	Native fine mineral
Trail drainage	Ponded
Mud and muck	Muck hole
Rutting	17 to 32 inches
Vegetation condition	Stripped

Compeau Trail, Chena River State Recreation Area (Alaska DNR)

Attribute	Value
Track type	Main
Track	Wide track
Impact width	6 to 12 feet
Trail grade	Contour 4 to 8 percent
Tread geometry	Outsloped
Trail surface character	Mixed fines and gravel
Trail drainage	Well drained
Mud and muck	None
Rutting	Less than 2 inches
Vegetation condition	Stripped

Quartz Creek Trail, White Mountains National Recreation Area (BLM)

Attribute	Value
Track type	Main
Track	Multibraid 2 to 4
Impact width	12 to 18 feet
Trail grade	Fall line 4 to 8 percent
Tread geometry	Outsloped
Trail surface character	Mixed fines and gravel
Trail drainage	Well drained
Mud and muck	None
Rutting	2 to 8 inches
Vegetation condition	Heavy impact

Quartz Creek Trail, White Mountains National Recreation Area (BLM)

Attribute	Value
Track type	Main
Track	Double wheel track
Impact width	3 to 6 feet
Trail grade	0 to 3 percent
Tread geometry	Flat
Trail surface character	Geotextile surface
Trail drainage	Well drained
Mud and muck	None
Rutting	None
Vegetation condition	Moderate impact

Figure 10–5—An example of four different trail segments and their condition assessment attributes and values for the feature TREADWAY.

OHV Trail Assessment Field Mapping

A data dictionary can be applied manually during field mapping or be incorporated with a mapping-grade GPS unit or mobile mapping system.

Field Mapping Using Manual Methods

In general, manual OHV trail assessments are most appropriate when:

- A single trail or very simple trail system is being evaluated.
- The trails are fairly short and uncomplicated.
- Heavy tree cover or steep terrain blocks GPS signals.
- Only the most rudimentary data are being collected.
- The mapping crew does not have access to, experience with, adequate training for, or agency support for more sophisticated mapping-grade GPS and mobile mapping systems.

To easily and consistently record field data, a field data form can be developed and a pick list (list of choices) created. Appendix E includes a blank condition assessment manual data sheet. Appendix E also has the "Condition Assessment Codes and Ranking Weights" pick list from the "Alaska OHV Condition Assessment Data Dictionary."

The manual field mapping method uses a measuring wheel or tape (high precision) or GPS trip computer or OHV odometer (low precision) to determine beginning and ending points for trail segments and locations for point features.

Measuring wheel or tape values would be expressed in the standard engineer's format: 00+00; where hundreds are denoted left of the "+" sign and distances between 0 and 99 feet are denoted right of the "+" sign. For example 1,235 feet would be recorded as: 12+35; and 63 feet would be recorded as 00+63. Trip computer and odometer data would be recorded in miles and the closest tenths of a mile; for example, 12.4 miles.

The manual data sheet in appendix E can be used to record coordinates from a GPS receiver. Note the blocks reserved for waypoint numbers. Individual waypoints can identify a trial segment's beginning and ending points, and the locations of trail-related point features.

The GPS data can be downloaded as a track log to represent the trail alignment. The track can be displayed and labeled on a topographic map using commercially available mapping software. The track log also can be downloaded as a shapefile (an attribute table with associated feature locations) for input into a GIS.

To ensure accuracy, record GPS waypoints as an averaged reading (a posting based on data collected for 10 seconds or longer). The waypoints can be used to identify the beginning and end of trail segments. Transfer between various data formats and software systems is improving as the popularity of GPS mapping increases. If a Garmin GPS unit is used, GPS data can be downloaded using a free software package developed by the Minnesota Department of Natural Resources called DNRGarmin (http://wwwtt.dnr.state.mn.us/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html).

With recreation-grade GPS receivers, waypoints can be individually labeled or assigned a symbol that can enhance the information displayed on final trail maps (figure 10–6).

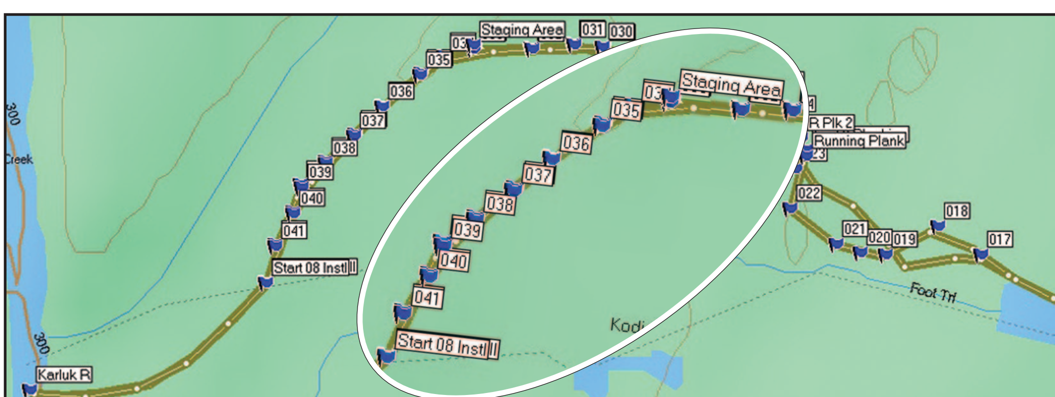


Figure 10–6—A map of a track log representing a trail alignment with waypoints defining trail segment breaks. The map was generated from data collected using a recreation-grade GPS receiver and displayed on a topographic base map. —*Base map produced using TOPO! ©2008 National Geographic.*

Field Mapping Using Mapping-Grade GPS and Mobile Mapping Systems

Because mapping-grade GPS receivers have better antennas, receivers, and internal processors, they are significantly more accurate and sophisticated than recreation-grade GPS receivers. Mapping-grade GPS receivers can use integrated data dictionaries and their accuracy can be refined with differential GPS correction (DGPS).

Differential correction is a method of comparing GPS satellite coordinates with a known base station's location. Any error in the satellite signal is corrected and automatically applied to the GPS data collected in the field. Differential correction can improve point accuracy to 1 meter or less.

Mapping-grade GPS receivers are designed to collect high-quality data, correct and refine the data with software packages, and export the data to a shapefile that is downloaded into a geodatabase (a relational geographic database used by GIS software). The geodatabase provides the platform for final data editing, analysis, display, and map production.

Mobile mapping systems are typically a rugged field computer or personal digital assistant (PDA) with a GPS receiver. The quality of the GPS antenna, receiver, and processor determine the accuracy and precision of the data.

Figure 10–7—Postprocessing data collected with mapping-grade GPS receivers can take twice the amount of time as the field data collection effort. The editing should be conducted with assistance from, or directly by, the field mapping crew.

Like mapping-grade GPS receivers, mobile mapping systems use an integrated data dictionary and can use differential correction. They collect high-quality data and can display georeferenced images, reference documents, calculations, and even integrated photography, depending on the type of system used. Their real strength is their ability to easily access and update existing files in a geodatabase.

This sophistication does not come without a downside. For every hour that a field technician spends collecting the data, a skilled GIS technician may need to spend 1 to 2 hours integrating the data into a GIS (figure 10–7).

Mobile mapping systems are an excellent way to monitor changes to baseline trail condition and record changes over time. Monitoring is discussed in more detail in "Element 10—Monitoring and Evaluation."

Figure 10–8 shows a mapping-grade GPS display of raw trail condition assessment data that was being edited using GPS software. Note the trail segment circled in red at the top of the image. The Feature Properties box to the right of the screen lists all attributes of that trail segment as it was mapped in the field. Similar data are available for every line, point, or area feature on the screen. Note also the data presented in the Position Properties box to the left, which includes latitude, longitude, precision, and date.

After the data have been edited, they are downloaded into the GIS software. Figure 10–9 shows GIS information of a trail alignment. Numbers identify individual trail segments. Segment numbers are cross-referenced to a data table (subsection shown in table 10–1) listing the features, attributes, and values for the trailway and the segment's starting point, ending point, length, and associated coordinates.

Condition assessment data is stored as a data layer in GIS software. The GIS software provides a visual display of specified tabular data, allowing great flexibility. For example, a GIS geodatabase can be queried to display trail segments that have trail grades steeper than 15 percent. This dataset can be queried to display trail segments that have ruts more than 4 inches deep. The new display of trail segments, which shows the relationship between steep grades and the depth of ruts can be used to evaluate erosion potential on steeper grades.

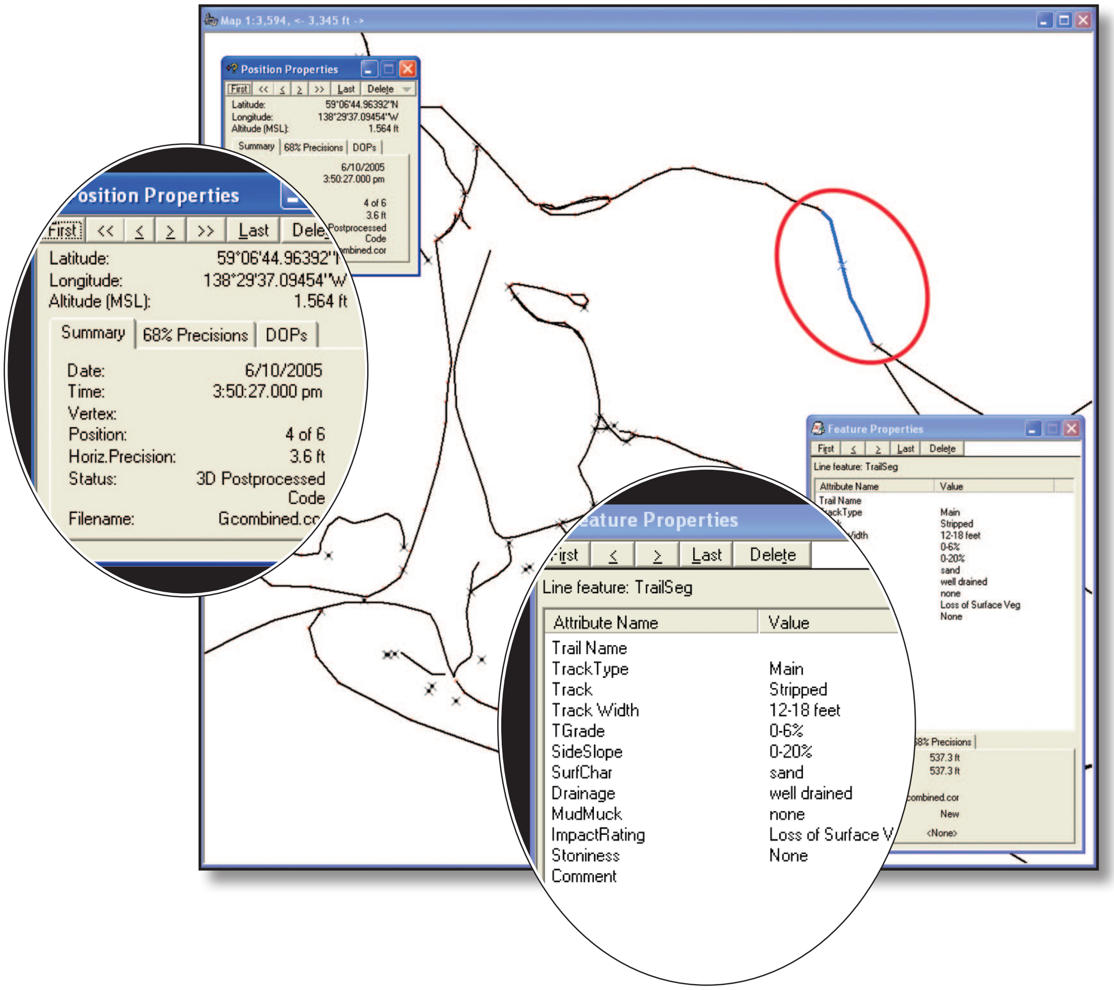


Figure 10–8—An example of a computer screen display of a complex trail system during the editing process. The properties listed in the data boxes relate to the circled trail segment. *—Information in the screenshots was generated using Trimble GPS Pathfinder Office software.*

Information from the trails data layer also can be combined with information from other resource or administrative data layers. For example, a query could be prepared to display the trail segments in designated wilderness (an administrative data layer) that cross wetlands (land cover data layer) and are within 50 feet of a stream (hydrology data layer). The ability of GIS software to manipulate combinations of data is limited only by the availability and detail of the data layers and by the skill of the GIS specialist.

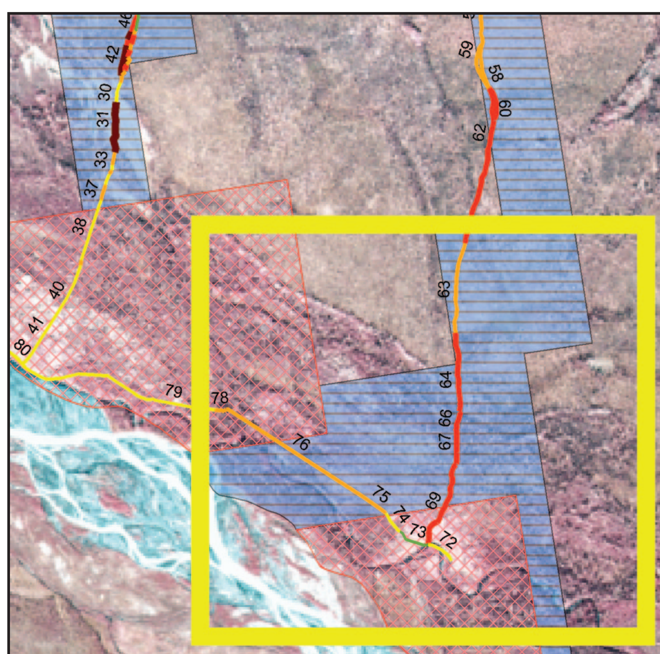


Figure 10–9—A GIS display of a trail alignment over a color-infrared image. Table 10–1 shows trailway information for the trail segments inside the yellow box (lower right corner of figure).

Table 10–1—GIS information for a trail alignment (TRAILWAY data for figure 10–9).

TRAILWAY (segment number)	Begin segment (feet)	End segment (feet)	Length (feet)	TGRADE (percent)	TSURFCHAR	DRAINAGE	MUDMUCK	RUTTING (inches)	TRACKTYPE	TWIDTH	SIDESLOPE (percent)	STONES
63	17405	18274	869	0 to 6	Native fine mineral	Poorly drained	None	9 to 16	Main	Stripped 6 to 12 feet	0 to 20	None
64	18274	18948	673	0 to 6	Native fine mineral	Poorly drained	Muddy	9 to 16	Main	Stripped 6 to 12 feet	0 to 20	None
65	18948	19030	83	21 to 40	Native fine mineral	Poorly drained	None	9 to 16	Main	Stripped 12 to 18 feet	0 to 20	None
66	19030	19212	181	7 to 20	Native fine mineral	Poorly drained	Muddy	9 to 16	Main	Stripped 6 to 12 feet	0 to 20	None
67	19212	19303	91	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Stripped 6 to 12 feet	0 to 20	None
68	19303	19413	110	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Multibraid 6 to 20 feet	0 to 20	None
69	19413	19959	546	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Stripped 6 to 12 feet	0 to 20	None
70	19959	20021	62	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Multibraid 6 to 20 feet	0 to 20	None
71	20021	20318	297	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Stripped 6 to 12 feet	0 to 20	None
72	20318	20595	278	0 to 6	Native fine mineral	Moderately well drained	None	Less than 2	Main	1 set wheel tracks	0 to 20	None
73	20595	20920	325	0 to 6	Mixed fines and gravel	Well drained	None	Less than 2	Main	1 set wheel tracks	0 to 20	None
74	20920	21148	228	0 to 6	Native fine mineral	Moderately well drained	None	2 to 8	Main	1 set wheel tracks	0 to 20	None
75	21148	21331	183	0 to 6	Native fine mineral	Poorly drained	Muddy	2 to 8	Main	Stripped less than 6 feet	0 to 20	None
76	21331	21422	91	0 to 6	Native fine mineral	Poorly drained	Muddy	2 to 8	Main	1 set wheel tracks	0 to 20	None

Trail Condition Categories

A trail manager looking at condition assessment data will quickly recognize certain patterns. For example, flat trail segments with areas of standing water may have deep ruts or bog holes. These segments would be considered degraded. Trail segments with grades between 4 and 12 percent, on well-drained, mixed fine and gravel soils may not have any evidence of tread degradation. These segments generally would be considered in good condition.

Data collected in the condition assessment can be used to sort trail segments into a range of trail condition categories. Standard categories include: good, fair, degraded, very degraded, or extremely degraded.

The “Alaska NPS OHV Condition Assessment Data Dictionary” (appendix F) lists sequential ranges of values for many attributes describing the physical character of a trail. For instance, the **impact width** (IMPACTWIDTH) attribute (the width of disturbance associated with trail use) has values beginning at less than 1.5 feet and ranging to more than 480 feet. The **track** (TRACK) attribute (the type of impression resulting from wheel passage) has values ranging from single track, to multibraided—more than 10 tracks. Similarly, the rut (RUTTING) attribute can range from less than 2 inches to more than 61 inches deep. These attributes, along with certain other attributes, can be used as indicators of trail degradation.

Each indicator of degradation was assigned a degradation ranking value. The fourth column of the “Condition Assessment Codes and Ranking Weights” pick list (see appendix E) displays the assigned degradation ranking weight. (Note: The weights reflect patterns of degradation in Alaska and may not reflect patterns of degradation in other regions.) Figure 10–10 displays the ranking weights of the individual values for the **impact width** attribute.

These ranking weights are based on the target design parameters in a TMO. In this case, the design specification for trail width was 6 feet. Wider trails are considered an indicator of degradation.

No degradation ranking weights were assigned if the segment was less than 6 feet wide. A ranking weight of 4 was assigned if the segment was 6 to 12 feet wide. The ranking weight increases as the width increases, up to a maximum weight of 20.

Impact width	Ranking weight
Less than 1.5 feet	0
1.5 to 3 feet	0
3 to 6 feet	0
6 to12 feet	4
12 to18 feet	10
18 to 24 feet	12
24 to 40 feet	15
40 to 80 feet	20
80 to 160 feet	20
160 to 320 feet	20
320 to 480 feet	20
More than 480 feet	20
Not indicated	0

Figure 10–10—A subset of the “Condition Assessment Codes and Ranking Weights” pick list (in appendix E—Forms), displaying the degradation ranking weight for the **impact width** attribute. The design width is 3 to 6 feet.

Table 10–2—Condition category assignments (based on cumulative ranking values).

Total ranking weight	Condition category assignment	Code
Less than 10	Good	G
10 to 24	Fair	F
25 to 49	Degraded	D
50 to 75	Very degraded	VD
More than 75	Extremely degraded	XD

Each trail segment accumulates a total degradation ranking value (figure 10–11). The degradation ranking process sorts the relative condition of trail segments numerically; the higher the ranking the more severe the degradation. The ranking is used to allocate each segment into one of the five trail condition categories. Table 10–2 shows the condition categories.

The condition category assignments for the two trail segments displayed in figure 10–11 would be very degraded for the segment with the ranking of 72 (photo shows an ATV in a muckhole), and degraded for the segment with the ranking of 36. The trail segment with the ranking of 72 is clearly significantly degraded. The second segment, although not as severely degraded, displays evidence of braided trail development and surface erosion. The segment's degraded condition category alerts trail managers to the potential of accelerated degradation at this site.

A trail condition category is assigned to each individual trail segment. If you are conducting a condition assessment inventory manually, the ranking weights are recorded in the row beneath the values for each segment on the "Manual Data Sheet" (see appendix E). The total value is recorded at the end of the row, and condition category assignments are entered in the last column. If GPS receivers and GIS are used, a table developed by a GIS specialist performs the calculations.

Figure 10–12 shows a trail map displaying trails with individual trail segments color coded based on their condition category. The color display provides an easily understood visual representation of trail conditions. Using colors (green/violet/yellow/orange/red) to show increasing degradation helps agency managers and the public quickly interpret the map.

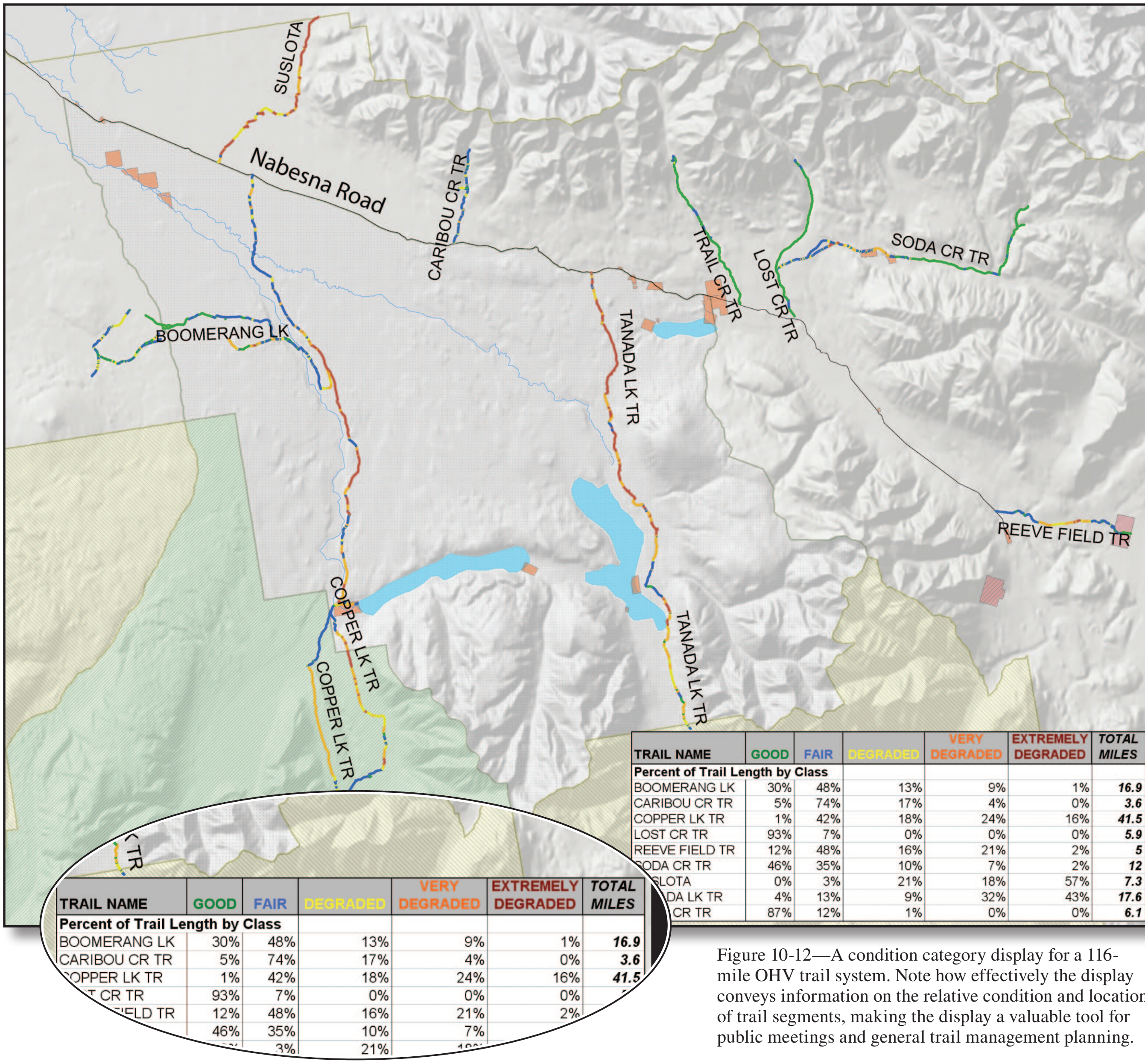
Reeve Field Trail, Wrangell-St. Elias National Park (NPS)

Attribute	Value	Ranking
Track type	Main	0
Track	Multibraid 5 to 10	20
Impact width	18 to 24 feet	12
Trail grade	0 to 3 percent	0
Tread geometry	Entrenched	NA
Trail surface character	Native fine mineral	6
Trail drainage	Ponded	8
Mud and muck	Muck hole	10
Rutting	17 to 32 inches	12
Vegetation condition	Stripped	4
	Total	72

Quartz Creek Trail, White Mountains National Recreation Area (BLM)

Attribute	Value	Ranking
Track type	Main	0
Track	Multibraid 2 to 4	15
Impact width	12 to 18 feet	10
Trail grade	Fall line 4 to 8 percent	4
Tread geometry	Outsloped	NA
Trail surface character	Mixed fines and gravel	0
Trail drainage	Well drained	0
Mud and muck	None	0
Rutting	2 to 8 inches	4
Vegetation condition	Heavy impact	3
	Total	36

Figure 10–11—Calculated total degradation ranking values for two trail segments.



TRAIL NAME	GOOD	FAIR	DEGRADED	VERY DEGRADED	EXTREMELY DEGRADED	TOTAL MILES
Percent of Trail Length by Class						
BOOMERANG LK	30%	48%	13%	9%	1%	***16.9***
CARIBOU CR TR	5%	74%	17%	4%	0%	***3.6***
COPPER LK TR	1%	42%	18%	24%	16%	***41.5***
LOST CR TR	93%	7%	0%	0%	0%	***5.9***
REEVE FIELD TR	12%	48%	16%	21%	2%	***5***
ODA CR TR	46%	35%	10%	7%	2%	***12***
LOTA	0%	3%	21%	18%	57%	***7.3***
DA LK TR	4%	13%	9%	32%	43%	***17.6***
CR TR	87%	12%	1%	0%	0%	***6.1***

Figure 10-12—A condition category display for a 116-mile OHV trail system. Note how effectively the display conveys information on the relative condition and location of trail segments, making the display a valuable tool for public meetings and general trail management planning.

Evaluating Sustainability of Trails

A detailed condition assessment provides data on five of the six sustainable trail design guidelines (table 10–3). For example, trail segments with grades steeper than 10 percent will not generally meet the controlled grade sustainable trail design guideline.

Table 10–4 may help managers determine the general sustainability category for an individual trail, based on certain criteria:

- To what degree the trail includes the sustainable trail design elements
- Condition category
- Frequency and adequacy of maintenance

Any of the criteria in the table can be modified to reflect local or regional conditions. A more sophisticated approach for evaluating the general sustainability category of a trail is explained in "Element 6—Evaluation of Management Options."

Table 10–3—Detailed condition assessment data for five sustainable trail design guidelines. Features and attributes are given in GPS format.

Guideline	Feature	Attribute	Values that meet guideline	Values that do not meet guideline
Contour curvilinear	TRAILWAY	TGRADE	Contour	Fall line
Controlled grade	TRAILWAY	TGRADE	Grades generally less than 10 percent	Grades generally more than 10 percent
Integrated drainage	AQUAMGT	TYPE	Water bar Grade dip Natural dip	NA
Integrated drainage	TRAILWAY	TREADGEO	Outsloped Convex	Flat Concave Entrenched
Durable tread	TRAILWAY	TSURFCHAR	Upland vegetation Native fine mineral Fines over gravel Mixed fines and gravel Alluvial sands and gravel Gravel Cobble Bedrock or rubble All hardened surfaces	Wetland vegetation Floating vegetation Native organic Sand Churned organics

Table 10–4—Guidance screening table (for sustainability categories). Sustainable trail design elements include contour alignment, controlled grade, integrated drainage, full bench, durable tread, and appropriate maintenance .

Design element status	Condition category	Receives regular maintenance	Receives adequate maintenance	Sustainability category
All present	Fair or good	Yes	Yes	Design sustainable
All present	Less than 10 percent degraded	Yes	No	Maintainable (likely upgradeable to design sustainable)
All present	More than 10 percent degraded	No	No	Maintainable (may be upgradeable to design sustainable)
Few or none	Fair or good	Yes	Yes	Performance sustainable (stable)
Few or none	Fair or good	No	No	Performance sustainable (at risk)
Partial	Fair or good	Yes	Yes	Likely maintainable
Partial	Fair or good	No	No	Likely maintainable
Partial	Up to 20 percent degraded	No	No	Likely maintainable
Partial	Up to 20 percent degraded	Yes	No	Possibly maintainable
Partial	20 to 33 percent degraded	No	No	Possibly maintainable
Partial	20 to 33 percent degraded	Yes	No	Likely unmaintainable
None	33 to 50 percent degraded	Yes	No	Likely unmaintainable
None	33 to 50 percent degraded	No	No	Likely unmaintainable
None	More than 50 percent degraded	Yes or no	No	Unmaintainable

Chapter 11: Element 6—Evaluation of Management Options

The evaluation of management options helps identify alternatives and guide decisionmaking for strategic trail planning and project implementation. The evaluation should consider the trail's social, political, and environmental context. The evaluation also benefits from a review of appropriate BMPs for OHV trails. Appendix D includes a list of BMPs.

Management Options for Planned OHV Trails

The management options for planned trail construction are different than those for existing trails. When constructing a new trail, a trail manager has more latitude in design, layout, and construction than when reconstructing an existing trail. Options for planned trails include:

- Take no action
- Construct a new trail
    - ✧ Focus on use characteristics
    - ✧ Configure the layout
    - ✧ Select the route

Take No Action

No action is always a management option when considering new trail construction. Typically, this option is a required alternative in any EA/EIS or other environmental review.

When the no action alternative is required for an environmental compliance document, the trail manager needs to be actively involved with the analysis of this alternative and document its positive and its negative consequences.

An agency that decides not to construct a trail may be able to reduce future maintenance costs and prevent wildlife habitat fragmentation. But if the trail is not built, its intended purpose will not be achieved. The trail may have been proposed to provide recreational opportunities or access, or the new trail may have been intended to relieve the strain on existing, less sustainable trail alignments. New trails may be proposed because of increased use or changing use patterns in the area. New OHV trails constructed using the sustainable trail design guidelines may demonstrate progressive trail design concepts and construction methods.

Occasionally a trail manager may need to oppose construction of a new trail. If the proposed site has poor soil or terrain characteristics, or the proposed trail cannot possibly be sustainable, the trail manager should highlight the consequences of building the trail, which may include placing a high demand on limited trail maintenance capabilities or posing an unnecessarily high risk to surrounding environmental values. There may be value in having certain areas free of OHV trails. The trail manager may advocate for other types of trails, if appropriate.

Construct a New Trail

If you decide to construct a new trail, you will want to focus on use characteristics, configure the layout, and select a route.

Focus on Use Characteristics

For planned OHV trails, managers have a range of choices from exclusive use by a single use type to unlimited and unrestricted multiple use. Use characteristics include: use type, OHV vehicle size and weight, volume of use, intensity of use, and season of use.

The TMO process (see "Element 3—Trail Management Objectives") should be used to identify use characteristics. The process should incorporate public involvement and an interdisciplinary agency analysis to identify designed use, managed use, allowable use, season of use, and trail design parameters. The use characteristics describe the range of use options for a trail and should reflect agency goals and user needs. The TRACS TMO does not specifically address volume and intensity of use. However, these may need to be considered with supplemental evaluations, especially if use tends to be concentrated during certain periods, such as hunting seasons, periods of high rainfall, or during large competitions or events hosted by specific user groups.

An environmental compliance team may also consider broadening or narrowing the use characteristics as alternatives in an environmental analysis. The trail manager must clearly outline the variation in tread requirements, trail maintenance costs, and potential environmental effects for each alternative.

It's important to consider the possibility of changes in the political climate, demographic shifts, increased use by a particular user group, or evolving technologies. An example of an evolving technology is the development of UTVs, which are becoming more common on OHV trails.

Configure the Layout

OHV trails generally are laid out to be either utilitarian or recreational. Sustainable trail design guidelines should be followed so that both utilitarian and recreational trails have a minimal impact on the environment and minimize maintenance costs.

Utilitarian trails, typically part of a transportation infrastructure, provide an improved route between two or more locations. Utilitarian trails may service a wide range of users. These trails can link a parking lot to a picnic area or a trailhead to a nearby overlook, lake, or another point of interest. While utilitarian trails are usually constructed to improve access, don't overlook esthetics in their design.

Recreational trails enhance the user's experience. The trail is more than simply a route to a destination or some other recreational experience.

Recreational trail layouts allow a great deal of latitude in designing trail flow, complexity, and challenge for a range of riding experiences. For example, mountain bike trails are designed by IMBA (2004) to be open and flowing, tight and technical, or a hybrid of the two:

> "**Open and flowing trails** are relatively gentle. They have long sightlines, gradual turns and few technical challenges. They appeal to less-skilled cyclists as well as those people who enjoy traveling fast. Open and flowing trails need long sightlines because they invite higher speeds and are attractive to motorized users.
>
> "**Tight and technical trails** have sharper turns and twists, rougher surfaces, a narrower tread, and natural obstacles. They provide challenges and thrills for mountain bikers while keeping speed down, which in turn may reduce user conflict. Tight and technical trails may frustrate hikers or destination-oriented hikers, and shortcutting may result."

IMBA defines a hybrid trail as a successful combination of the open and flowing and the tight and technical trail. Figure 11–1 illustrates these types of recreational trails.

IMBA strongly supports controlled grade limits (10 percent or less average grade) and does not feel that steeper trails are required for great riding opportunities. IMBA's approach to designing mountain bike trails also applies to recreational OHV trails. By the same token, well-designed

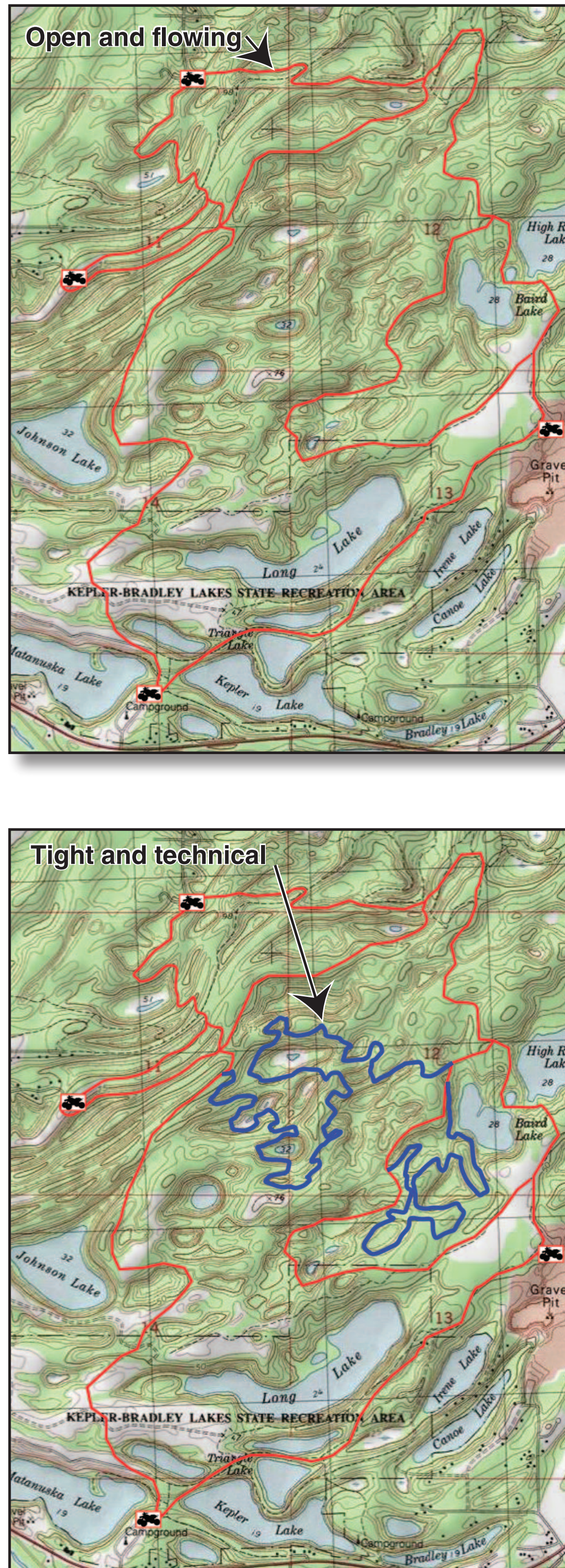


Figure 11–1—Examples of open and flowing (red), and tight and technical (blue) trail layout configurations. —*Base map produced using TOPO! ©2008 National Geographic.*

OHV trails can also provide good opportunities for biking and hiking.

The National OHV Conservation Council (NOHVCC) in its 2006 publication “Management Guidelines for OHV Recreation” (Crimmins 2006, http://www.nohvcc.org/IMAGES/ohvguidelines.pdf) mirrors many of the IMBA concepts. NOHVCC reinforces the application of sustainable trail design elements including contour alignments, grade control, and integrated drainage. The NOHVCC publication also lists seven trail layout configurations that can be used to enhance the recreational experience: linear, single loop, stacked loop, multiple loop, spoked wheel, primary and secondary loop, and maze systems (figure 11–2). In addition to information on layout options, the NOHVCC document

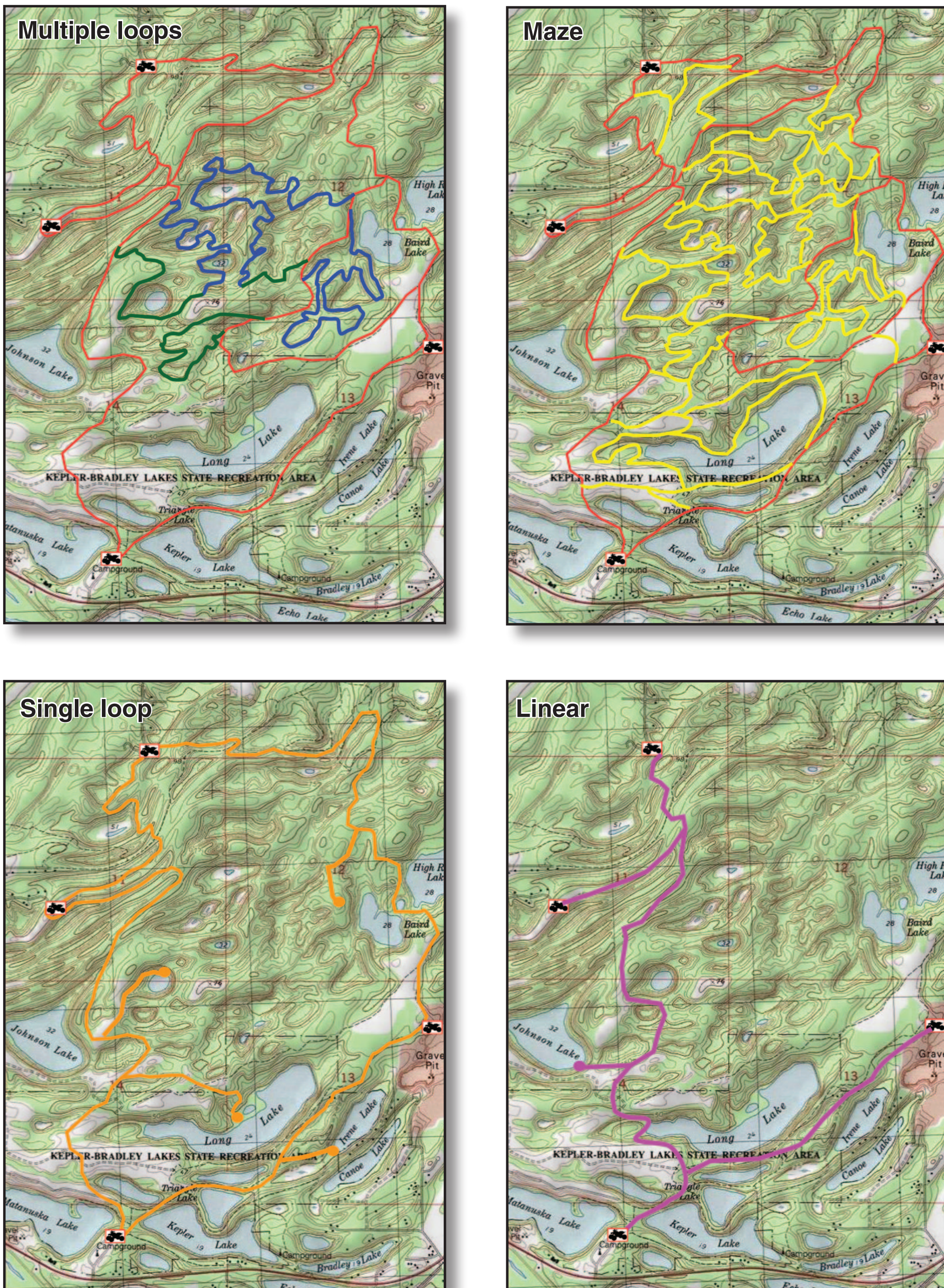


Figure 11–2—Examples of four trail configurations (multiple loops, maze, single loop, and linear). —*Base map produced using TOPO! ©2008 National Geographic.*

covers OHV trail planning and design, and provides a valuable overview of OHV trail management.

Another valuable resource for recreational OHV trail design and layout is “Off-Highway Motorcycle and ATV Trails: Guidelines for Design, Construction, Maintenance and User Satisfaction” (Wernex 1994). This document provides an excellent overview of recreational OHV trails from a user’s perspective. Wernex has incorporated many of the sustainable trail design principles. These include controlling grade and incorporating water control using grade dips or grade reversals. This document is available from the American Motorcyclist Association at http://www.ama-cycle.org/legisltn/downloads/WernexReport.pdf.

Wernex further suggests that exposure along the trail—locations where there would be serious consequences if a rider should fall or lose control—adds to the range of experiences. Table 11–1 is a summary of some of Wernex’s eight elements of difficulty. Although the table does not include trail alignment, sideslope, and isolation, these elements can be incorporated into trail design to change difficulty levels.

The Minnesota Department of Natural Resources’ (DNR) “Trail Planning, Design, and Development Guidelines” (2007) will also be helpful to OHV trail planners and designers. This comprehensive publication covers a wide range of trail types and presents its own framework for planning sustainable trails.

Table 11–1—A summary of some of Joe Wernex’s “Trail Bike Trail Difficulty” elements. —*Adapted with permission from the American Motorcyclist Association.*

Aspect	Easiest	More difficult	Most difficult
Grade	Maximum sustained pitch 8 percent Maximum pitch 15 percent	12 percent 30 percent	15 percent 50 percent (rare)
Minimum clearing width	Downhill side 2.0 feet Uphill side 3.0 feet Level each side 1.5 feet	1.5 feet 3.0 feet 1.5 feet each side	1.5 feet 2.5 feet 1.5 feet each side
Minimum clearing width (wooded)	Downhill side 2.0 feet Uphill side 3.0 feet Level each side 2.0 feet	1.5 feet 3.0 feet 2.0 feet each side	1.5 feet 2.5 feet 1.5 feet each side
Clearing height	9.0 feet	8.0 feet	8.0 feet
Tread width	Minimum 18 inches[1] Maximum 30 inches	18 inches 24 inches	12 inches 24 inches
Tread surface	Relatively smooth throughout, no rocks or roots protruding more than 3 inches Avoid sand and loose materials	Some segments relatively rough Some loose sand, etc.	Relatively rough with some segments very rough Long stretches of loose rock and sand, etc., desirable on occasion.

[1]Increase tread width 6 to 20 inches on switchbacks or where sideslopes exceed 50 percent. Trails for ATV use will have to be widened accordingly. ATV trails will generally not include the slopes seen in the most difficult category. The trail becomes less structured and more primitive as it progresses from easiest to most difficult.

The Minnesota DNR adapts Wernex's "Trail Bike Trail Difficulty" chart and expands it to include curve radius, mud surface, and separate tread surface character for ATVs, off-highway motorcycles, and general OHVs. The Minnesota DNR also identifies maximum grades (figure 11–3) allowed for short pitches and length restrictions for the difficulty classes.

Let's take some time to examine the terms "difficulty," "class," and "challenge" a little more closely. These terms are used somewhat interchangeably to describe the skill level required to ride a particular trail. Wernex uses the terms "easiest," "more difficult," and "most difficult" to describe trails with increasingly steeper grades, narrower clearings and tread width, and rougher tread surfaces.

Aspect	Easiest	More difficult	Most difficult
Grade	8 percent maximum sustained 15 percent short pitch (~25 feet long maximum) 25 percent very short pitch	12 percent maximum sustained 25 percent short pitch (~15 feet long maximum) 35 percent very short pitch	15 percent maximum sustained 35 percent short pitch (~12 feet long maximum) 50 percent very short pitch (rare)

Figure 11–3—"OHV Tread Guidelines for Difficulty Levels." —*Courtesy of Minnesota DNR. Adapted from Joe Wernex's "Trail Bike Trail Difficulty" chart and modified for OHV travel and Minnesota conditions.*

Trail Grades Steeper Than 10 Percent

Both Wernex and the Minnesota DNR would allow trail grades steeper than 10 percent on more difficult and most difficult trails. Trail grades steeper than 10 percent are more susceptible to degradation from erosion and to having the surface tread displaced by the torque of OHV tires. The soil used as a surface tread material needs to be carefully evaluated before constructing alignments on grades of 10 to 15 percent and even more carefully evaluated on grades steeper than 15 percent. Additional mitigation for steeper grades could include placing water control structures closer together, increasing maintenance intensity and frequency, and improving durability of the tread surface.

A trail manager needs to recognize that OHV trails with average trail grades steeper than 10 percent do not meet the sustainable trail design guidelines promoted in this report. Designing trails with higher average grades is certainly within a manager's prerogative but doing so carries a greater management responsibility. Before building steeper trails, an OHV trail manager needs to answer two questions:

- Are steeper grades—with their increased susceptibility to degradation—required for a challenging riding experience?
- Can the manager **ensure** that the agency will always have the resources to provide for the higher level of tread maintenance, upkeep of water control structures, or hardened tread surfaces needed for steeper grades?

If the trail manager cannot answer both questions with a resounding "yes," the trail design should follow the sustainable trail design guidelines.

Additional Resources

Troy Scott Parker, president of Natureshape LLC, has designed and built trails for the National Park Service, Forest Service, The Nature Conservancy, and others. Parker writes and publishes trail books, provides trail book reviews, trail-related training and workshops, consulting, and trail design services.

Natureshape.com has valuable information on trail design and construction including:

- "Natural Surface Trails by Design: Physical and Human Design Essentials of Sustainable, Enjoyable Trails. Natural Surface Trails by Design." 2004. 80 p. This "how-to-think" book dives deep into the foundation of trail design. Parker introduces the concept of trailshaping to teach trail workers, volunteers, designers, and planners how to see and analyze complex information and solve problems in most sites or locations. The term "trailshaping" and other trail design language introduced in the book can help communicate the details of trail design.
- "Trails Design and Management Handbook." 1994. 228 p. Troy Scott Parker wrote this design guide for Pitkin County, CO. He includes information on multiple-use concrete/asphalt trails, crushed stone trails, boardwalks, and other trail topics.
- "Trail Planning, Design, and Development Guidelines." 2007. 300 p. Troy Scott Parker wrote the natural surface portions of this comprehensive guidebook on trail planning, design, construction, and maintenance. The guidebook was written for the Minnesota Department of Natural Resources. It is intended to help land managers apply new, innovative, and environmentally sustainable approaches to trail planning, design, and construction.

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There is a general correlation between the Forest Service ATV design parameters for trail classes 2 through 4 and the design specifications for Wernex's difficulty levels. The only major difference is that trail class 2 identifies trail grades up to 25 percent, while Wernex's most difficult level tops out at 50 percent. The Forest Service does stipulate that grade should be based on soils, hydrological conditions, use levels, other factors contributing to surface stability, and erosion potential. The agency further stipulates that steeper pitches must be carefully evaluated.

In general, OHV trails with 15 to 25 percent average grades do not meet sustainable trail design guidelines unless they are on rock or an equally durable tread surface. For example, the Forest Service manages steep, sustainable OHV trails on bedrock surfaces in the desert Southwest.

Table 11–2 presents a challenge matrix for new sustainable OHV trails that includes three ATV challenge levels. This matrix, expanding on Wernex's elements of difficulty and the Forest Service trail classes, defines additional parameters and options. An OHV trail manager can use these options to provide a wide range of riding experiences while ensuring long-term sustainability and low maintenance costs.

Table 11–2—Challenge matrix for new OHV trails meeting sustainable trail design guidelines.

Element	Least challenging	More challenging	Most challenging
Average grade	3 to 6 percent	6 to 9 percent	9 to 12 percent
Maximum grade (based on specific site conditions for durability of tread)	Up to 15 percent	Up to 15 percent (up to 25 percent is allowed for some segments on extremely durable tread)	Up to 15 percent (up to 35 percent is allowed for some segments on extremely durable tread)
Length of maximum grade	Up to 50 feet for no more than 5 percent of the total trail length	Up to 50 feet for no more than 10 percent of the total trail length	Up to 50 feet for no more than 15 percent of the total trail length
Width			
Off-highway motorcycle	18 to 30 inches	18 to 24 inches	12 to 18 inches
ATV	6 to 9 feet	5 to 7 feet	4 to 6 feet
4-wheel-drive vehicle	10 to 12 feet	8 to 10 feet	7 to 8 feet
Tread outslope			
Typical	3 to 6 percent	3 to 6 percent	3 to 6 percent
Range	3 to 8 percent	3 to 12 percent	3 to 20 percent
Design speed	Up to 20 miles per hour	10 to 15 miles per hour	Less than 10 miles per hour
Flow	Open and flowing	Tighter and more technical	Tightest and most technical
Variation—vertical and horizontal direction changes (may be a water control component)			
Frequency	Low, less than 50 per mile	Moderate, 50 to 70 per mile	High, more than 70 per mile
Magnitude	Shallow and gentle	Noticeable, occasionally steeper and more abrupt	Frequently steep and abrupt
Interrelationships	Usually separate changes in horizontal and vertical alignments	Occasional combined changes in horizontal and vertical alignments	Frequent combined changes in horizontal and vertical alignments
Optional challenge sites (large irregular rocks, rock climbs, mud pits, log crossings, narrow bridges, loose sand, water features, extreme outslope)	Occasional, low-challenge rock gardens, rock slabs, choke points, tree obstacles or other features Alternative route to avoid low-challenge obstacles	Frequent, mixed low- and moderate-challenge rock gardens, rock slabs, chokes points, tree obstacles or other features Alternative route to avoid moderate-challenge obstacles	Frequent, mixed moderate- and high-challenge rock gardens, rock slabs, choke points, tree obstacles or other features Alternative route to avoid high-challenge obstacles
Curves			
Radius	25 to 30 feet minimum	15 to 25 feet minimum	Less than 15 feet occasionally
Geometry	Flat	Flat and superelevated	Flat and superelevated
Type	Simple	Climbing/sweep	Climbing/sweep, occasional switchback
Natural sideslope	Less than 30 percent	Up to 60 percent	Up to 150 percent

Table 11–2 (continued)

Element	Least challenging	More challenging	Most challenging
Clearance minimums			
General	3 to 6 feet	1.5 to 3 feet	As little as 1.5 feet
Uphill	4 to 7 feet	3 to 6 feet	1.5 to 3 feet
Trees	All cleared	Occasional within clearing	Common within clearing
Clearance height (higher if the trail is also used in winter)	9 feet	8 feet	8 feet
Sightlines	Long and open	Moderate and occasionally obscured	Short and frequently obscured
Multiuse	Possible	Discouraged	Restricted
Tread roughness (variations may be greater in challenge sites)	Generally smooth with a few variations Variations 2 to 4 inches	Some segments rough with occasional variations Variations 2 to 5 inches	Generally rough with frequent variations Variations 2 to 6 inches
Isolation	Low degree of isolation Numerous signs Trail is close to front country or developed as a primary travel corridor with many other users	Moderate degree of isolation Occasional signs Trail is far from front country Trail is a secondary travel corridor with reduced use	High degree of isolation Few signs Trail is remote and far from primary travel corridors
Design exposure to hazards	Tread design and maintenance presents very low hazard from falling or loss of control Open and flowing alignment and unobstructed sight distances may result in excessive speed issues	Tread design and maintenance presents low hazard from falling or loss of control Optional challenge features may result in a low to moderate hazard of falling or loss of control, generally without serious consequences to the rider	Tread design and maintenance presents low hazard from falling or loss of control Optional challenge features may result in a moderate hazard of falling or loss of control, generally without serious consequences to the rider

Select the Route

The final management option when planning a new trail is route selection. Although at first it might appear there are a wide range of routes where a new trail could be placed, the choice usually is constrained by administrative, social, technical, terrain, and environmental factors. Table 11–3 provides a partial list of these constraints.

In general, constraints that affect trail location are called major control points. The trail should be located near positive control points, while negative major control points should be avoided. Control points can be points, lines, or areas.

Typically, positive and negative control points are plotted on a base map used to identify a potential corridor (or corridor options) for the trail. This process, called preliminary trail layout, is described in more detail in "Element 7—Trail Prescriptions."

Table 11–3—Factors affecting route selections.

Administrative
Land ownership Existing infrastructure—trailheads, roads, parking areas, camp sites Land use classifications Connections with other trail systems
Terrain
Lakes and ponds Uncrossable rivers and streams Terrain barriers—cliffs, unstable slopes Wet areas Flat areas Poor quality surface soils Exceedingly steep sideslopes Extremely dense vegetation cover Suitable sites for stream crossings
Social and technical
User group(s) requirements Specified challenge level Design specifications—grade, width Sustainable design criteria Buffers for private land, highways, etc.
Environmental
Wetlands Critical habitats—plants and animals Cultural resource sites Sensitive waterways Coastal zones Invasive species Habitat fragmentation Noise and air quality conflicts

Typically, the alignment option that best accommodates the TMO, major control points, and sustainable trail design guidelines would be the preferred option. Alternative alignments may also be identified for environmental compliance.

Management Options for Existing Trails

Managing existing trails is more complex than managing newly constructed trails. The goal is to determine the management options that are most appropriate.

Options include:

- Take no action
- Modify use controls
- Increase maintenance and mitigate impacts
- Close the trail

Take no action—The no action management option is appropriate for existing trails when existing use does not degrade the trail or the environment, condition trends are positive or neutral, and users' needs are met. Nothing needs to change.

Modify use controls—Use controls affect type, volume, and seasons of use. Restricting certain types of use can be an appropriate management option when the type of use is the source of degradation. The simplest restriction is setting weight and width limits for vehicles. These restrictions help control the physical size of vehicles (figure 11–4) and may allow the trail width to be limited.

Controlling the amount or intensity of use is appropriate when overuse is causing degradation. Trailhead parking or onsite sanitation facilities also may be too limited to support the level of use.

Determining appropriate use levels can be difficult. There may not be a linear relationship between use levels and impact. After a certain level of use has been reached, trail conditions may continue to degrade even if the trail is closed.

Restrictions on seasons of use are appropriate when the durability of the trail surface is strongly affected by conditions that vary with the season, such as surface moisture or ground temperature. Typically, trail surfaces are most sensitive when soils are saturated with water. Surface tread is typically saturated during spring thaw and fall freezeup, and may be saturated during periods of heavy rainfall.

Figure 11–4—The wide range in OHV sizes, weights, and potential for surface impact may make specific use restrictions advisable. This photo shows the contrast between two types of OHVs commonly used in certain areas of Alaska.

In other areas, use during dry seasons may cause dust problems or winds may displace trail surface materials. Temporarily closing trails during periods when the trail is most sensitive may significantly reduce trail degradation.

Increase maintenance and mitigate impacts— Increased maintenance and project level mitigation are the appropriate management actions when they address degradation and the costs are reasonable. This can include modifying the frequency, type, and intensity of maintenance. It can also include work such as reconstruction, rerouting, or trail hardening to construct a more sustainable trail tread. The level of resource investment in project work determines whether a trail is maintainable or design sustainable.

Close the trail—It's appropriate to permanently close trails that are unmaintainable. Temporary trail closures may be needed for maintainable trails and even design-sustainable or performance sustainable trails when funding does not allow adequate maintenance.

However, trail closures are not popular. Identify alternatives such as reconstruction, rerouting, trail hardening, or seasonal or type-of-use restrictions and discuss them in a public forum. Trail managers should discuss compliance issues, agency budgets, and workforce limitations that may affect management alternatives. Agencies should also be prepared to direct users to more sustainable trails or to discuss replacing the trail.

User groups may be willing to accept some responsibility for maintaining the trail, mitigating some of the problems, or implementing necessary trail improvements. This assistance may prevent or delay trail closure.

Enforcement of restrictions or closures is important. Wilderness CPR has an article "Six strategies for Success: Effective Enforcement of Off-Road Vehicle Use on Public Lands" (Archie 2007, http://www.wildlandscpr.org/files/SixStrategiesReport.pdf, 6.5-megabyte Acrobat file).

Analysis Flowchart

Analysis of the management options for existing trails include three steps:

- Step 1—Determine whether the trail meets its TMO.
- Step 2—Assess the trail's physical condition.
- Step 3—Evaluate the trail for sustainability.

The "Analysis Flowchart" (figure 11–5) provides more details about this three-step analysis.

Step 1—Determine Whether the Trail Meets Its TMO

When trail use matches the use characteristics specified in the TMO and the tread matches the design parameters, the trail meets its TMO (see figure 11–5, Step 1).

If the trail does not comply with its TMO, the trail manager should determine the changes that are needed to the trail's use characteristics or its physical design so the trail will comply.

It is important to determine the costs of these changes. For use characteristics, the costs may be social or political. For design parameters, the costs are typically labor and materials. If the costs are reasonable, evaluation can continue. If the costs are excessive, the trail manager needs to take one of three actions:

- Temporarily accept the inconsistency with the TMO
- Modify the TMO to better reflect existing conditions
- Close the trail

Accepting conditions that are inconsistent with the TMO is seldom desirable, but may be necessary until further evaluations (Steps 2 and 3) are conducted. Modifying the

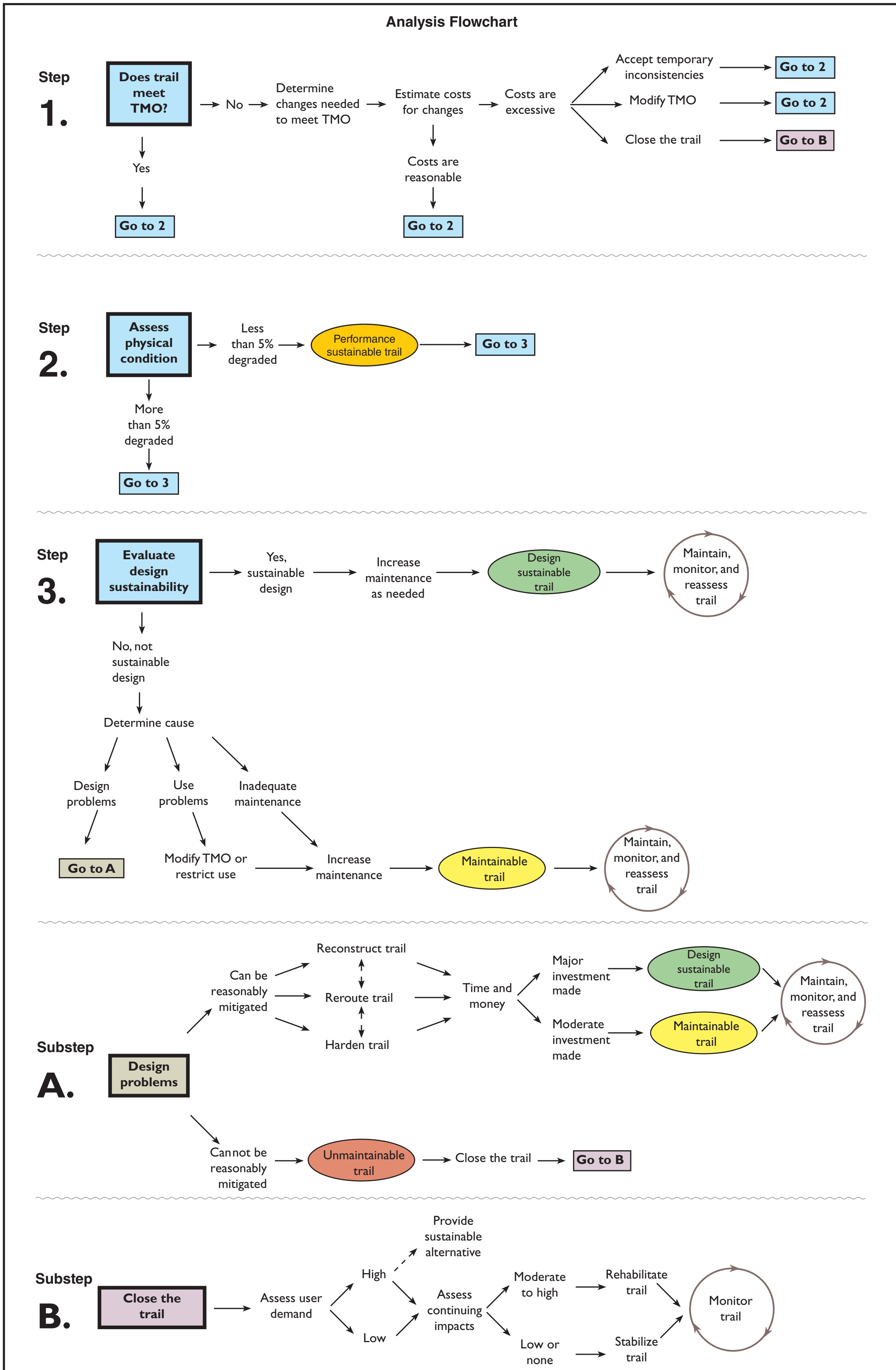


Figure 11–5—Analysis Flowchart for existing trails.

TMO may be appropriate in situations where use patterns or agency trail management objectives have changed. Closing a trail because it does not meet its TMO is undesirable, but may be necessary if resources are not available to meet management objectives or if continued trail use would cause significant impacts.

Step 2—Assess the Trail's Physical Condition

If the trail complies with its TMO, if temporary inconsistency with the TMO is acceptable, or if the TMO is modified, the trail's physical condition is assessed (see figure 11–5, Step 2).

If the trail meets its TMO objectives and 95 percent or more of the entire trail is in good or fair condition, the trail is at least performance sustainable. This does not guarantee that trail conditions will remain stable, so the trail should be evaluated for its design sustainability.

Both performance and design sustainable trails need regular maintenance, monitoring, and occasional reassessment under Step 1.

If more than 5 percent of the trail is degraded, move to Step 3.

Step 3—Evaluate the Trail for Sustainability

Evaluate how well trail segments comply with sustainable trail design guidelines for contour alignment, controlled grade, integrated drainage, full bench construction, and durable tread. This evaluation provides the trail manager with a better understanding of why a trail is or is not performing well (see figure 11–5, Step 3).

A trail meeting sustainable trail design guidelines may have some degradation if routine maintenance is inadequate. In many cases, an increase in maintenance frequency, type, or intensity may correct problems. After maintenance is completed, the trail would be considered design sustainable.

If trails do not meet sustainable trail design guidelines, evaluate the problems that may have caused them to become degraded and determine the management actions that are needed to correct them. Usually degradation is caused by design, use, or maintenance problems.

Causes of Trail Degradation

Design Problems

- Trails have a fall-line alignment (not a contour alignment).
- Trails exceed the sustainable grade.
- The alignment has inadequate water control structures.
- The tread is constructed on less than a full bench and the tread foundation is failing.
- The trail tread is not constructed on durable soils.
- The trail is poorly located.

Use Problems

- Type of use is inappropriate for trail design.
- Volume or intensity of use exceeds design capacity.
- Use occurs during an inappropriate season or during unfavorable weather conditions.

Maintenance Problems

- Trail receives no maintenance.
- Maintenance is inadequate or infrequent.
- Maintenance has been performed incorrectly, or it's the wrong type or intensity.

If the trail does not meet sustainable trail design guidelines and the degraded conditions are caused by inadequate maintenance, increasing the level or modifying the type of maintenance may solve the problem. If degradation issues can be managed through a reasonable increase in maintenance, the trail is considered maintainable.

Design problems may need to be addressed and will require more detailed analysis and evaluation (see figure 11–5, Substep A). The trail manager needs to determine how much the existing trails deviate from the sustainable trail design guidelines and the degree of degradation. This evaluation should identify whether or not the design problems can be mitigated.

Address design problems that can be reasonably mitigated through some combination of trail reconstruction, rerouting, and hardening. These projects typically take longer and cost more than routine maintenance but are needed to address design problems.

Table 11–4 summarizes common problems affecting OHV trails and the solutions to those problems.

Determining the best response to minor design problems depends on local site and trail conditions, agency capabilities, and financial resources. **Reconstruction** is most appropriate when the trail design comes close to meeting sustainable trail design criteria and degradation is not too extreme. For instance, a trail with long gentle grades may be degraded because of inadequate water control. A cost-effective solution might be to reshape the tread with a series of rolling grade dips.

Rerouting is appropriate when a trail can be relocated readily to more durable soils or better terrain. A good example would be relocating a trail from a wetland to a nearby upland. Decisions to reroute a trail require a thorough onsite evaluation of surrounding vegetation, soils, and terrain. Study soil surveys, aerial photos, and land cover maps for additional information.

When rerouting a trail, use sustainable trail design, layout, and construction practices. Figure 11–6 shows a trail that is a good candidate for rerouting. Figure 11–7 displays rerouting alternatives.

Table 11–4—Summary of OHV trail issues, problems, and solutions. Possible alternative solutions common to all three issues include implementing user controls or closing the trail.

Issue	Problem	Solutions
Very steep grades	Water erosion Tread surface displacement from wheel torque Ruts and braiding	Reroute the segment to reduce the grade Increase water control Increase maintenance Increase durability of the tread
	Too steep to accommodate multiuse	Reroute the segment to reduce grade
Wheel tracks form on the tread surface	Wheel ruts defeat the outslope and channel water along the trail causing increased erosion and tread loss	Increase maintenance frequency to reshape the tread Increase water control by constructing rolling grade dips
Excessive speed	Decreased safety Tread displacement Formation of superelevated or banked turns	Narrow the trail clearing width Increase sinuosity Introduce challenge Increase maintenance
Flat grades	Tread entrenchment Water collection and pooling Muddy surface conditions and ruts Braided trail development	Reroute the segment to sidesloped terrain Increase durability of the tread (trail hardening) Improve drainage

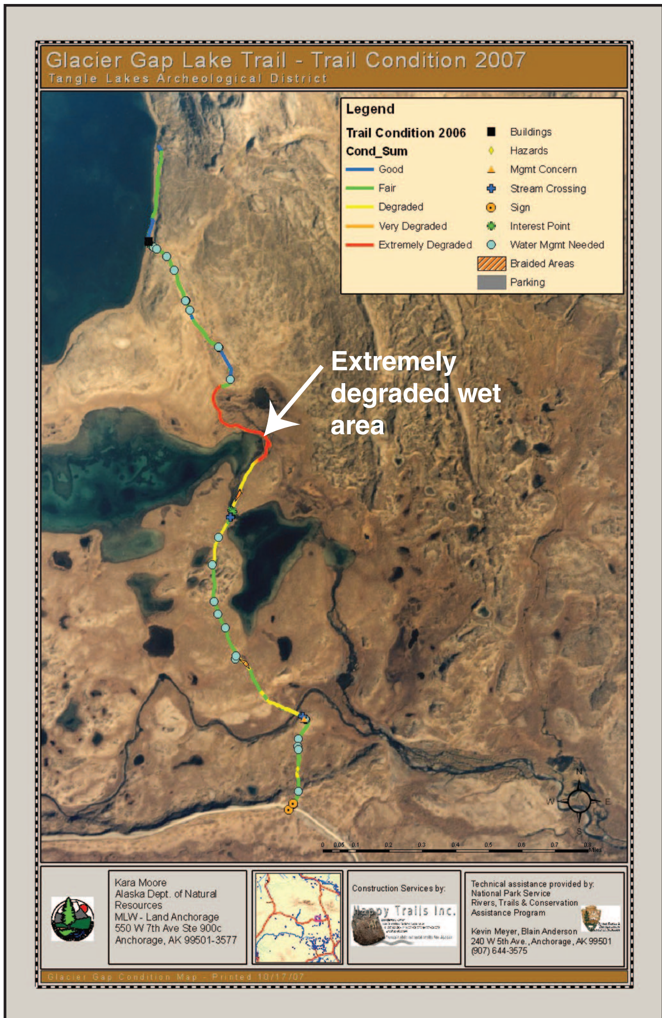


Figure 11–6—An image of a trail alignment with its (colored) condition class assignments. Note the extremely degraded trail segment (red). This segment crossed an extensive wetland with no viable tread improvement options.

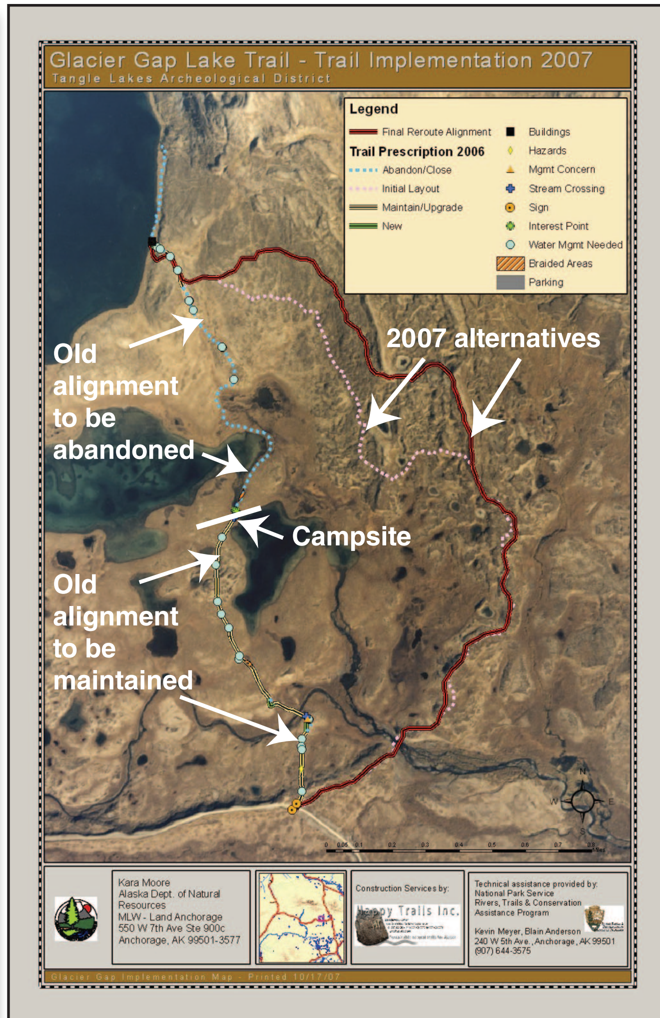


Figure 11–7—The same trail with two reroute alternatives located on uplands to the east. The alternative (dark red) was constructed in 2007 using sustainable trail design guidelines. The old alignment is slated for partial abandonment/closure and partially for maintenance and upgrade. The retained portion will be used to provide access to the lower lake and a stream between the lakes. A small undeveloped campsite is located at the terminus of the retained portion of the old trail.

Trail hardening (figure 11–8) improves a substandard tread surface by replacing or augmenting the surface, or capping it with gravel. Rerouting should be considered first because trail hardening is expensive. Trail hardening is appropriate when trail segments are:

- Degraded or do not provide a durable tread surface
- Causing or may cause unacceptable environmental impacts
- Difficult to reroute because alternative trail locations are not available, environmentally acceptable, or economically feasible

Appendix B includes a detailed discussion of trail hardening methods.

Figure 11–8—A trail-hardened surface of porous pavement panels provides passage over permafrost-associated wetlands on the Karluk River Portage Trail within Alaska's Kodiak Island National Wildlife Refuge.

Trail Hardening Basics

The benefits of trail hardening include:

- Defines a single alignment for vehicle travel
- Stabilizes surface conditions along the hardened trail segment
- Provides a stable, durable trail surface for OHV and other traffic
- Prevents widening of trails and the development of braided trail segments
- May allow abandoned areas to stabilize naturally
- May allow for vegetation growth (or regrowth) within the hardened trail surface

Methods of trail hardening include:

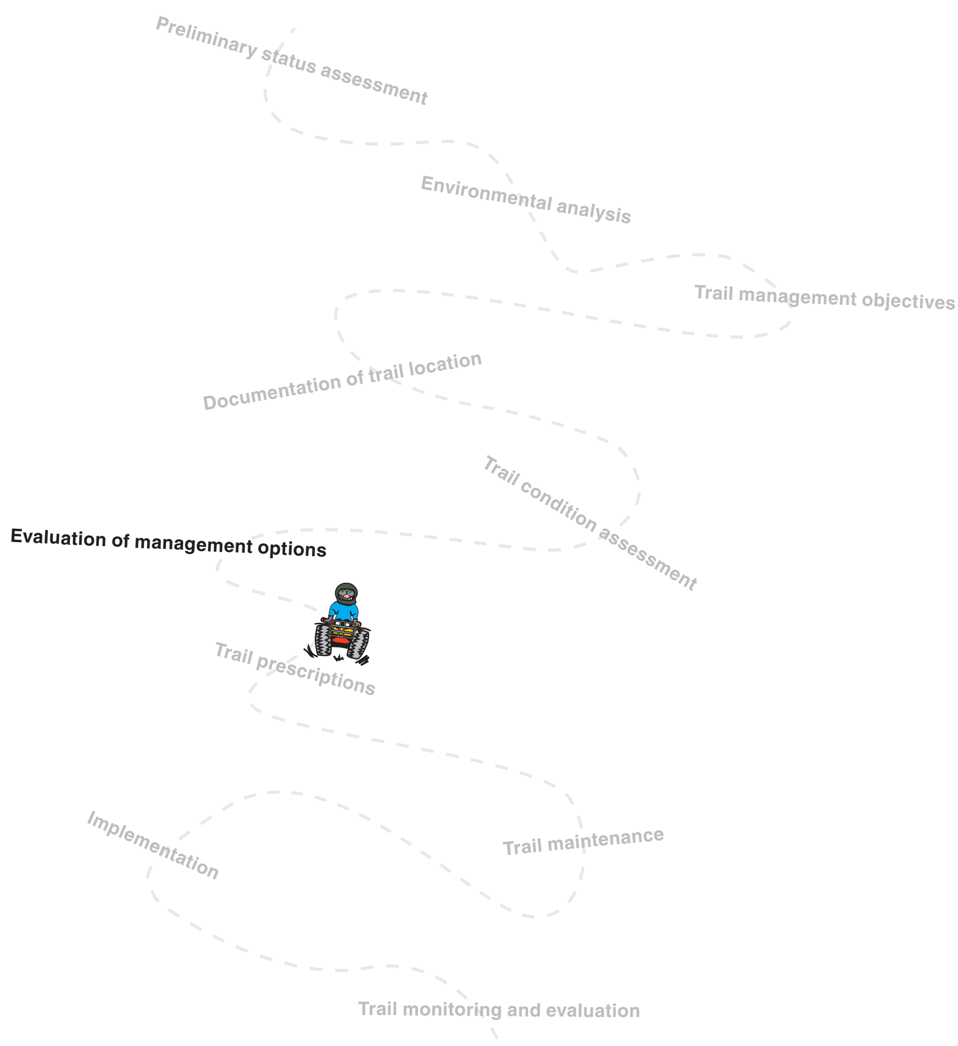
- Gravel capping with or without a geotextile underlayment
- Turnpike
- Causeway
- Boardwalk or puncheon
- Running plank
- Wood chips or chunkwood surfacing
- Paver blocks
- Porous pavement panels
- Surface paving

Trails that can be reconstructed, rerouted, or hardened at a reasonable cost are considered maintainable or even design sustainable. Trails with design problems that cannot be reasonably mitigated by reconstruction, rerouting, or hardening are unmaintainable.

Generally, unmaintainable trails should be closed (see figure 11–5, Substep 5). Assess user demand before closing any trail. If user demand is high, provide a sustainable alternative to the closed trail.

Even after a trail has been closed, it may continue to degrade or have other environmental impacts. If the impacts are low, the trail should be stabilized so it can restore itself. If the impacts are moderate or high, the closed trail should be rehabilitated with water control, vegetation plugs, seeding, and fertilization, or other methods of rehabilitation. In either case, closed trails should be monitored for any continued degradation.

Whether a trail is design sustainable, performance sustainable, or maintainable, it should be maintained regularly and be monitored for degradation and TMO compliance. Periodically, the trail should be reassessed using Steps 1 through 3 of the flowchart.



Chapter 12: Element 7—Trail Prescriptions

A trail prescription defines the appropriate actions for new trail construction and maintenance of existing trails. This prescription forms the implementation plan for the trail. A condition assessment supports the prescription, especially if a draft or final TMO has not been developed for a trail. Condition assessments are discussed in "Element 5—Trail Condition Assessments."

A TMO identifies the uses a trail is managed for. Trail Management Objectives are discussed in "Element 3—Trail Management Objectives."

Knowing the types of OHV that use a trail is critical. Actual and planned volume and intensity of use also need to be considered. Periods of high use also should be identified. Use may be evenly distributed over a season or concentrated during brief periods—sometimes when weather is unfavorable. Uses may include organized recreational events such as fun runs or poker runs, or heavy use over holiday weekends or during the hunting season.

The trail design should take into consideration the season of the year when most use will occur. Manage the trail primarily for that season. For example, if the managed use occurs early in the spring when the tread is easily degraded, the trail may need to be designed and constructed to provide a more durable surface or may require more frequent maintenance.

Table 12–1 shows an example of trail use characteristics and use controls for the fictional Bob White multiuse trail. The specific use data may validate the TMO or may point out the need to consider modifying or refining the TMO.

Developing prescriptions for new construction or maintenance of existing trails requires a high level of trail expertise. For new construction, expertise is required on sustainable trail design concepts and layout methods. For maintenance, expertise is required to identify the cause of maintenance issues, conduct an engineering evaluation

When a Trail Assessment Is Needed

A trail assessment is needed in some situations before developing a trail prescription:

- When establishing a management program for a trail.
- When poorly developed or managed trails present complex management issues that need to be fully understood before specific prescription actions are identified. Mixing condition assessment with prescription development can complicate inventory, mapping, and analysis. Worse yet, it can lead to specifying prescriptions that may not be appropriate, given future management.
- When local trail experts are not available to determine the best maintenance or mitigation actions needed to address trail degradation or resource damage. Such experts are often in short supply. Condition assessments do not require as much expertise as development of prescriptions because they involve measuring and recording rather than exercising judgment.
- When a developed set of prescriptions for a trail changes over time. These changes may occur because of changes in management direction, lack of funding or resources, long delays before implementation, changes in mitigation techniques, or differences in interpretation among trail experts who developed the original prescription and the staff who are attempting to implement it. Unless a prescription is based on an existing TMO and the maintenance program is active and adequately funded, a prescription may become outdated.
- When it may be more appropriate to consider a wider range of management options. Separating condition assessments from prescriptions, especially on poorly developed or managed trails, can encourage trail managers to explore a wider range of options rather than continually pumping maintenance dollars into an unmaintainable trail alignment.

Table 12–1—Trail use characteristics for the fictional Bob White multiuse trail.

Use type	Width limit (feet)	Gross vehicle weight (pounds)	Season of use	Volume of use
4-wheel-drive vehicle	7 to 8	Up to 4,000	Spring breakup	Prohibited
			Summer	Prohibited
			After fall freeze	Less than 4 per day (hunting) by permit only
2-wheel-drive ATV	5 to 6	Up to 1,200	Spring breakup	Prohibited
			Summer	About 100 per day
			After fall freeze	Prohibited
4-wheel-drive ATV	5 to 6	Up to 1,600	Spring breakup	Prohibited
			Summer	About 50 per day
			After fall freeze	Estimated 100 passes
Off-highway motorcycle	2 to 3	Up to 700	Spring breakup	Prohibited
			Summer	About 50 per day
			Rider Rally Day (July 4th) 3 days	About 250 per day by 3-day permit
			After fall freeze	Prohibited
Mountain bike	2 to 3	Up to 300	Spring breakup	Prohibited
			Summer	About 20 per day
			National Trails Day (Memorial Day)	About 175 by 1-day permit
			After fall freeze	About 5 per day
Foot travel	2 to 3	NA	Spring breakup	Less than 10 per day
			Summer	10 to 40 passes per day
			After fall freeze	20 passes per day (10 hunting)

of bridges and other trail structures, identify appropriate corrective actions, and tailor actions to the capability and capacity of available maintenance resources.

Trail Design Parameters

Trail design parameters or specifications are the foundation of trail prescriptions. Design parameters direct new construction and guide maintenance of existing trails (figure 12–1). Parameters include tread width, grade, surface character, clearing limits, and trail riding character.

Required trail design parameters can be found in appendix H, which also includes a set of design specifications for a standard utilitarian summer-use OHV trail.

Figure 12–1—A trail crew uses handtools to shape the final tread surface to meet the design specifications.

Prescriptions—New Trails

A major task in building new trails is identifying the trail construction corridor. A trail construction corridor can be 25 to 50 feet wide or more, including lands on either side of the centerline of the proposed trail alignment. The construction corridor forms a buffer area around the proposed trail alignment, allowing the trail centerline to be adjusted as needed when the trail is being constructed.

Figure 12–2—This public use cabin would be a positive major control point during the preliminary trail layout.

Layout

Layout configurations (utilitarian and recreational) were discussed in "Element 6—Evaluation of Management Options." During layout, the best possible route is identified for a new trail or for a trail section that is being rerouted. Major control points help define options when laying out the trail corridor. Examples of positive major control points include: a good trailhead location, an area with soils of good quality, a popular scenic overlook, or the alignment of an existing trail to a lake or campsite. Examples of negative major control points include: a private property boundary, a cliff edge, a wetland, or an endangered species nest site. Figures 12–2 and 12–3 provide examples of positive and negative major control points.

To help identify control points, review the BMPs (see appendix D). The BMPs provide guidance for routing considerations and are useful references during trail layout.

All major positive and negative control points along the proposed trail route should be plotted on a map. Depending on the nature of the project, the complexity of the area, and the detail of available data, mapping the control points usually narrows the range of trail corridor options.

Figure 12–3—Cottongrass is an indicator of wetland conditions. This wetland meadow would be identified as a negative major control point.

Basic Considerations for Layout

Layout is the most critical element affecting the long-term management of the trail. A good layout enhances users' experiences, helps control construction costs, and minimizes long-term maintenance requirements. Layout is worth a major investment in both time and effort considering the tens of thousands of dollars that will be spent on construction and long-term maintenance. Remember, a trail has a service life of a hundred years or more. Do not skimp on applying the analysis, necessary expertise, and field time to do the best layout possible.

- Lay out trails using the sustainable trail design guidelines: curvilinear alignment, controlled grade, integrated drainage, full bench construction, and durable tread.
- Locate trails on upland, sloped terrain as much as possible. Avoid flat areas (less than 3 percent sideslope) because of problems associated with trail entrenchment and drainage. Avoid the steepest areas (sideslopes steeper than 80 percent) because trails become less stable as sideslopes become steeper.
- If possible, locate trails on sites with sideslopes between 10 and 30 percent (16 to 40 percent in parts of Alaska). The lower limit ensures enough slope for water control techniques to be used. The upper limit helps reduce the amount of material excavated in bench cuts and the need for extensive structures to stabilize the backslopes. Building trails on sideslopes steeper than 16 percent in Alaska helps compensate for the thick organic surface layers common in some areas.
- Locate trails on the upper third of sideslopes, if possible. Placing trails near the top of slopes reduces the volume of water intercepted as sheet flow from areas above the trail and allows trails to cross drainages near their upper reaches, reducing the need for major water crossing improvements.
- Use climbing turns for changes in direction rather than switchbacks (see appendix I).

Additional Resources

Alaska Trails provides technical assistance on trail-related projects and programs such as trail development, trail maintenance, easement acquisition, and safety. The nonprofit organization also offers educational materials and training information, including some publications by Mike Shields.

Mike Shields joined the National Park Service in 1960 as a seasonal laborer. He worked as a trails leader, ranger, interpreter, general foreman, facility manager, and chief of maintenance in many national parks, including Olympic, Grand Canyon, Big Bend, Canyonlands, Natural Bridges, North Cascades, Sequoia-Kings Canyon, Rocky Mountain, and Denali.

Shields' publications sold by Alaska Trails include:

- "Backcountry Stream Crossings." 2007. 64 p.
- "Turns: Design and Layout." 2007. 32 p. (See appendix I for excerpt.)
- "Slope Structures and Trail Stability." 2008. 30 p.
- "Trail Design and Layout." 2008. 52 p.
- "Trail Drainage Structures and Hydrology." 2008. 48 p.
- "Trail Treadway Structures." 2008. 56 p.

For additional information about Alaska Trails, contact:
Alaska Trails
P.O. Box 100627
Anchorage, AK 99510
Phone: 907–334–8049
Web site: http://www.alaska-trails.org

There are two types of climbing turns. Standard climbing turns are constructed on 6- to 15-percent sideslopes. Cut-through climbing turns (also called sweep turns) are used on 16- to 22-percent sideslopes. Turns on sideslopes steeper than 22 percent require extensive entrenchment. Sideslopes steeper than 22 percent usually require switchbacks. Avoid switchbacks for OHV trails, if possible, because of poor traffic flow and extremely high construction costs. Identifying good locations for climbing turns is critical during initial layout. Topographic features such as rises along ridge crossings, knobs, and small hill-like features can sometimes be used rather than constructing turns to change direction. These topographic features should be identified as positive minor control points.

The next step during layout is to consider terrain, soil type, surface vegetation, tree canopy, and other site conditions. If detailed geology, hydrology, soil, and land cover inventories are available, these should be studied to identify favorable and unfavorable conditions. Studying detailed aerial photography or satellite imagery also can help. Table 12–2 provides information on general site suitability.

Climbing Turns

Climbing turns (figure 12–4) are often constructed incorrectly. The typical problem is that a climbing turn is built (or attempted) on terrain that is too steep. Climbing turns allow a radius turn of 15 to 20 feet in appropriate terrain and are relatively easy to construct. Appendix I describes the required construction methods.

Trails that serve OHV traffic often use insloped, or banked turns so that riders can maintain their speed. The tread should be full-bench construction. To prevent shortcutting, wrap the turn around natural obstacles or place guide structures along the inside edge of the turn. The psychologically perfect place to build climbing turns is through dense brush or dog-hair thickets of trees, but be sure to provide adequate sight distance throughout the turn.

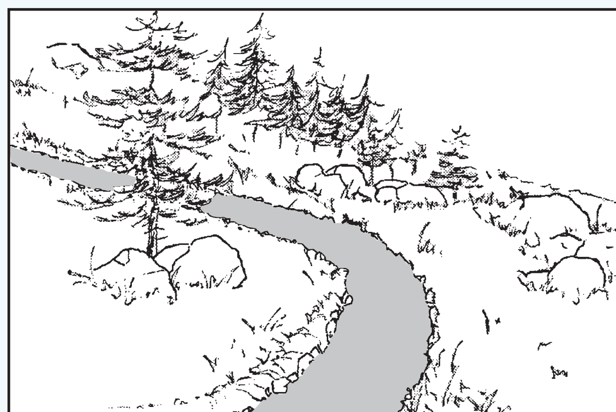


Figure 12–4—Climbing turns continue the climb throughout the turn and they should be insloped. Add grade reversals at both approaches to keep water off the turn.

—Adapted for OHV trails from the “Trail Construction and Maintenance Notebook” (Hesselbarth and others 2007).

Table 12–2—Trail site suitability matrix.

Elements	Generally good	Generally moderate	Generally marginal	Generally unsuitable	Comment/mitigation
			Terrain		
Slope	10 to 45 percent	3 to 10 and 45 to 60 percent	0 to 3 and 60 to 80 percent	More than 80 percent	For Alaska, 16 to 45 percent when a thick surface vegetation mat is present More than 80 percent has major excavation and backslope stability issues
Aspect	Southern (in northern climates)	Eastern Western	Northern (in northern climates)	No aspect is totally unsuitable	None
Position	Upper sideslopes	Mid to lower sideslopes	Flat valley floors Footslopes Ridgelines	Areas with active slides or rockfalls	Ratings are subject to slope considerations Flat areas may require trail hardening
Landscape type (partial listing)	Mostly well to moderately well drained upland sites High gravel bars and terraces	Active floodplains and outwash plains	Old lake basins Depressions Dunes Active alluvial fans	Areas with active slides, erosion, or rockfalls	Ratings are subject to slope and other site considerations
Hydrologic influence	Occasional shallow swales and drains with low water flow	(Nothing specified)	Deep, steep gullies and drains with frequent high water flow	Steep-walled gullies with frequent flash floods	None
			Soil		
Soil type	Most mineral soils	(Nothing specified)	Organic	(Nothing specified)	Organic sites may require trail hardening
Soil texture	Mixed rocky or gravelly	Loamy Silty	Clayey Sandy	(Nothing specified)	Poor quality soils may require capping, augmentation, or trail hardening
Large rocks	Few, deep	(Nothing specified)	Many, at surface	Extreme rockiness	Extreme situations may require capping or major construction actions
Soil depth	More than 30 inches	10 to 30 inches	Less than 10 inches	(Nothing specified)	None
Soil moisture	Moist	(Nothing specified)	Consistently dry or saturated	Frequently ponded	Sensitivity of saturated and ponded sites depends on soil texture May require fill or trail hardening

Table 12–2 (continued)

Elements	Generally good	Generally moderate	Generally marginal	Generally unsuitable	Comment/mitigation
Soil (continued)					
Water table depth	More than 30 inches	18 to 30 inches	Less than 18 inches	Frequently ponded at the surface	Persistent shallow water table sites may require trail hardening
Permafrost	None	Deep, ice free	Shallow, ice rich	Rapidly decaying	Marginal sites typically require trail hardening
Soil stability	Stable	(Nothing specified)	Loose, unstable	Sites of soil flows (including solifluction) or soil creep	None
Vegetation					
Vegetation type	Most upland vegetation communities	Most mesic types Some alpine sites	Some alpine sites Wetlands Floating vegetation	Sites with rare or endangered species	Wetlands and floating vegetation sites may require trail hardening
Large trees	Few, well spaced	Many, well spaced	Many, tightly spaced	Pistol grip or leaning	Many large, tightly spaced trees may require extensive clearing and construction operations
Vegetation mat thickness	Less than 4 inches	4 to 8 inches	More than 8 inches	More than 16 inches	Deep vegetation mats may require removal and fill or other trail hardening technique

Preliminary Route Selection

After major control points have been identified, preliminary routes are drawn on the base map and around key control points (figure 12–5). If the route crosses major terrain features, it can be divided into sections at major topographic breaks (ridges, toeslopes, valleys, and saddles) with grades calculated between topographic breaks. The complexity of the layout increases dramatically when major terrain features are crossed.

The trail grade along the proposed alignment can be calculated by identifying points on the topographic map that fall at major terrain transitions.

Using a topographic map to provide distance and elevation data, the average grade between two points can be calculated. Percent grade equals:

$$\frac{\text{Elevation (higher point)} - \text{elevation (lower point)}}{\text{Distance between the points}} \times 100$$

This provides the average grade between the two points as a percentage. Because grade is a critical element of the sustainable design guidelines, a preliminary trail layout should not be steeper than 8 percent. The 8-percent grade allows for the inclusion of grade reversals and minor adjustments in the final on-the-ground layout.

In addition to the 8-percent upper limit for preliminary layout, a lower limit of 3-percent grade allows adequate trail drainage. To meet this guideline, the trail must be on an area with a natural sideslope steeper than 6 percent (satisfying the half rule—trail grade should not exceed half the steepness of the sideslope to avoid a fall-line alignment).

If the proposed trail location is on sideslopes gentler than 6 percent, try to relocate the alignment to a steeper area. If that is not possible, the trail may have to be elevated and crowned to increase tread durability.

If the calculated grade between two points is more than 8 to 10 percent, the layout needs to be modified. Sometimes it’s as simple as adjusting the alignment so the trail does not ascend or descend as quickly. It may also be possible to adjust the grade of an adjacent trail segment. For example, if an adjacent segment has an average trail grade of 5 percent, it may be possible to increase the grade of that segment to 6 or 7 percent and decrease the grade of the steeper segment.

In some cases, trail segments need to be lengthened to reduce their grade. For an 8-percent grade, the length of trail needed between two points can be calculated based on the difference in elevation between two points. Length needed equals:

$$\frac{\text{Elevation change} \times 100}{8}$$

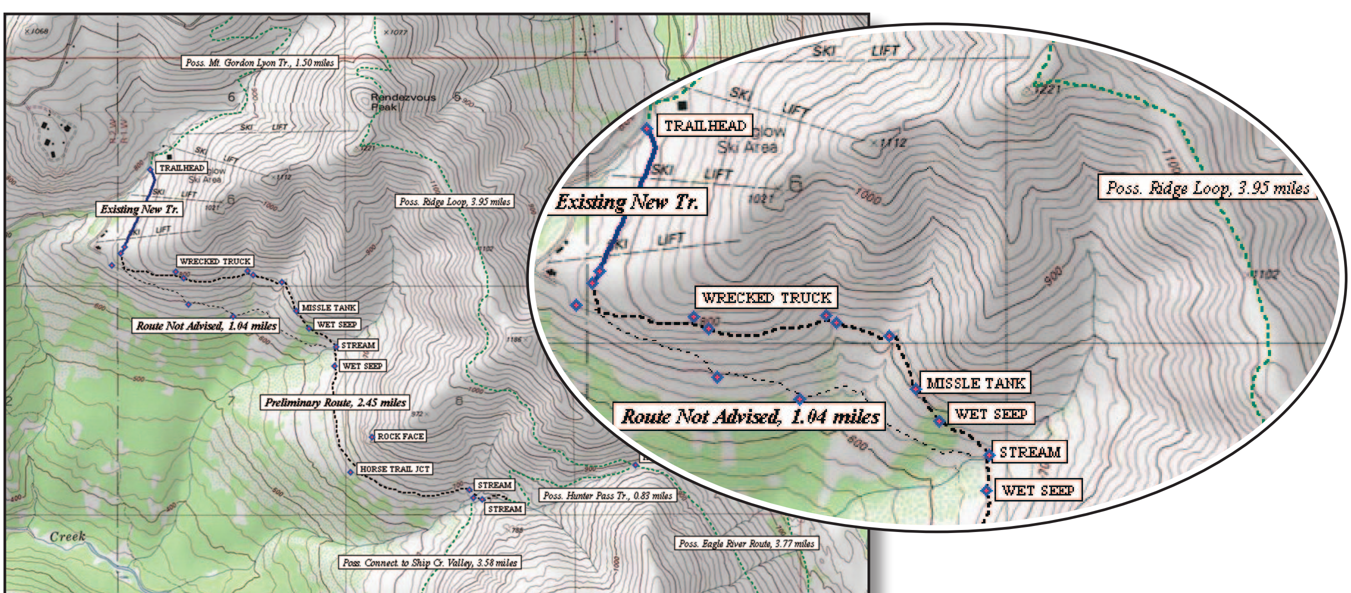


Figure 12–5—A topo map with a proposed trail alignment showing key control points. —*Base map produced using TOPO! © 2008 National Geographic.*

When terrain and conditions permit, length can be added to a segment between control points by integrating one or more climbing turns in the layout.

Many off-the-shelf or free topographic mapping software packages can help during preliminary route layout. The software can calculate trail length, sideslopes, and trail grade and display elevation automatically for various layout alternatives.

Figure 12–6—This bear den discovered during trail layout reconnaissance would become a negative minor control point.

On-The-Ground Layout

At this point, a field investigation is needed to inspect the preliminary route and identify minor control points, such as the locations of climbing turns and major topographic breaks. Minor control points can be positive or negative and consist of point, linear, or area features.

Minor control points are usually too small to be identified on topographic maps, resource inventories, or aerial photos. Whether a control point is positive or negative is far more important than whether it is major or minor. Figures 12–6 and 12–7 show examples of minor control points that might be identified during field investigation.

Figure 12–7—An area of excellent soil conditions may be identified as a positive minor control point.

Table 12–3 lists examples of positive and negative minor control points that should help guide field investigations. Some control points such as exposed bedrock and cultural or historic resources can be positive or negative, depending on circumstances. Table 12–4 provides additional information on sideslope considerations during field investigation. Note the sideslope limitations for climbing turns and cut-through climbing turns. An upper limit of 22 percent is recommended for cut-through climbing turns. Identifying locations large enough to accommodate a 15-foot radius (30-foot diameter) climbing turn is a critical objective during trail layout (figures 12–8 and 12–9). Appendix I provides details on the layout of climbing turns.

Table 12–3—Examples of positive and negative minor control points. Type of feature: P = point, L = line, A = area.

Positive control points	Type of feature	Negative control points	Type of feature
Terrain is between 10 to 30 percent	A	Terrain has less than 3-percent sideslope	A
Climbing turn platforms 10 to 22 percent	P	Terrain has more than 80-percent sideslope	A
Good stream crossing locations	P	Cliffs, sudden dropoffs	P or L
Good abutment sites for bridges	P	Unstable slopes	P or A
Exposed bedrock	P or A	Exposed bedrock	P or A
Good ridge crossing point	P or A	Shallow bedrock	P or A
Excellent soils	A	Wetlands	A
Low passes, saddles	P or A	Seep zones, pocket bogs	P or A
Trail junctions	P	Stream confluences	P
Good campsites	P or A	Active landslide areas	P or A
Good overlooks, viewpoints	P	Major avalanche tracks	P or A
Right-of-way corridors	L	Unstable scree	P or A
Easement corridors	L	Weak or unstable soils	A
Unique natural feature	P or A	Ice-rich or frost active soils	A
Cultural or historic resources	P or A	Cultural or historic resources	P or A

Layout Tools and Equipment

- Clinometer
- Altimeter
- GPS (recreation grade)
- Magnetic compass
- 50-foot tape
- 12-foot tape
- Laser rangefinder
- Small hand ax or saw
- Soil spade, probe
- Compact binoculars, monocular
- Digital camera (integrated GPS optional)
- Two-way radios with integrated GPS
- Extra batteries
- Base map, imagery
- All weather notebook, data sheets
- Tech notes on layout, turns, and similar technical matters
- Pens, pencils, wax crayon, permanent markers, spray paint, aluminum tag markers
- Flagging
- Pin flags, stakes, lath
- Also handy: High-visibility cruiser vest and cap, zip-seal plastic bags, backpack, raingear, bug repellant, sun block, gaiters, mid-weight mountaineering boots, water bladder and tube drinking system, energy bars, and lunch!

Table 12–4—Sideslope considerations.

Sideslope (percent)	**Tread location suitability**	**Recommended average trail grade** (percent)	**Maximum sustainable trail grade**[1] (percent)	**Half rule**	**Tread geometry**	**Turn location suitability**	**Turn type**	**Tread**	**Maximum distance between water control structures** (feet)[2]
0 to 2	Not recommended[3]	1.0 to 2.0	2	NA[4]	Crowned	Suitable	Simple/banked	Elevated (recommended)	NA
3 to 5	With caution[5]	2.0 to 5.0	5	NA[4]	Crowned/ outsloped	Suitable	Simple/banked	Elevated to full bench	125 to 175
6 to 15	Good	3.0 to 7.5	4 [6]up to 15	Applies	Outsloped	Suitable	Climbing	Full bench	100 to 150
16 to 22	Ideal	[7]3.0 to 10.0	[8]15	Applies	Outsloped	Suitable	Cut-through climbing	Full bench	75 to 125
23 to 30	Ideal	[7]3.0 to 10.0	[8]15	NA[9]	Outsloped	Marginal	Cut-through/ switchback	Full bench	75 to 125
31 to 60	Suitable	[7]3.0 to 10.0	[8]15	NA[9]	Outsloped	Not recommended	Switchback only	Full bench	75 to 125
61 to 80	Marginal[10]	[7]3.0 to 10.0	[8]15	NA[9]	Outsloped	Not recommended	Switchback only	Full bench with retaining walls	75 to 125
More than 80	Not recommended[10]	[7]3.0 to 10.0	[8]15	NA[9]	Outsloped	Highly not recommended	Switchback only	Full bench with retaining walls	75 to 125

[1] Up to 50 feet, not to exceed the percent of the total trail length specified in the design specifications.
[2] May vary, depending on climate, weather, and site conditions.
[3] Flat slopes are prone to surface failure—water pooling and degradation—and often require supplemental trail hardening.
[4] On low gradients, the half rule cannot be practically applied because it is difficult to control traffic moving across shallow slopes.
[5] Low gradient slopes are also prone to surface failure, and it's difficult to restrict shortcutting across climbing turns required by the half rule.
[6] Maximum trail grade of up to 15 percent allows for climbing turns on this slope class; but in general, the maximum sustainable tread grade for ascending tread should not exceed 75 percent of the sideslope. Also see 8 below.
[7] Grade may be slightly increased (1 to 2 percent) at sites with very resilient soil conditions or a high level of maintenance.
[8] Maximum sustainable trail grade depends on local site conditions, such as soil type, hydrology, and use characteristics. Grades steeper than 15 percent generally require naturally durable or artificially hardened surfaces.
[9] Average 10 percent trail grade standard overrules the half rule on slopes steeper than 20 percent.
[10] Large backslope excavations may require installation of crib walls to stabilize backslopes.

Figure 12–8—A clinometer is used during trail layout reconnaissance to measure sideslope (see table 12–4).

Figure 12–9—Measuring the turn radius with a tape is the best way to ensure that the sideslope area is large enough to accommodate the entire climbing turn layout.

Water control features should be integrated into the trail alignment to control erosion. Grade reversals are the best way to control water on OHV trails and should be placed along the alignment at roughly regular intervals. Here's how to integrate grade reversals into the layout of an ascending segment:

> For every 75 to 125 feet of climbing (+3 to +10 percent) grade, lay in a 15- to 20-foot segment of descending (-3 to -5 percent) grade, followed by another 75- to 125-foot climbing segment before repeating the pattern. If possible, the lowest point of the grade reversals should be at naturally occurring terrain drainages.

For descending trail segments, it's just the opposite. The trail should descend at a grade of -3 to -10 percent for 75 to 125 feet and then ascend at a grade of +3 to +5 percent for 15 to 20 feet before descending again. Water will be forced off the trail at each point where the grade reverses (figure 12–10).

Make sure there is a distinct change from a negative to positive grade at the bottom of the reversal and that the grade does not just level out. A level grade at the bottom will not force the water off the alignment. Instead, the water will run across the level segment and continue its descent down the trail. At the reversal point, the combined difference between the ascending and descending grades should be at least 6 percent.

Figure 12–10—This trail displays the stair-step alignment that is characteristic of integrating grade reversals when ascending or descending a sideslope.

Even when the trail is simply traversing a sideslope, do not lay the trail out with a 0-percent grade. Rather, lay out a long (75 to 125 feet), gentle (+3 to +5 percent) ascending trail segment, followed by a gentle (-3 to -5 percent) descending segment that is about as long. Grade reversals will be at the low points of this subtle elongated W-shaped layout (figure 12–11). The rise and descent provide enough grade to move water off the trail at the grade reversal points. This W-shaped layout minimizes the number of reversal points required along the alignment, reducing long-term maintenance of these critical drainage features.

Vary the spacing between grade reversals somewhat to keep the spacing from becoming unnaturally repetitive. Duplicate natural drainage as much as possible and mimic landform patterns to enhance the natural feel of the alignment. Troy Scott Parker's publication "Natural Surface Trails by Design" (2004) provides advice on enhancing the esthetics of trail design and layout.

When grade reversals are being laid out, use a clinometer to ensure accurate grade control. Do not trust your eye!

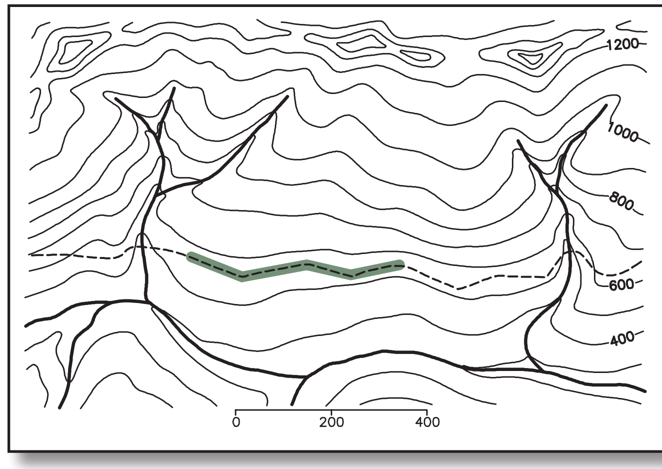


Figure 12–11—A W-shaped layout.

Rolling grade dips are another method of drainage control. Rolling grade dips can be used to supplement grade reversals during new construction in some situations. "Rolling Grade Dips for Drainage of OHV Trails" (Poff 2006) describes the technical details of constructing rolling grade dips (see appendix I).

Tips for Layout Crews

- Do not trust an eyeball guess for grade; always use your clinometer (clino).
- Heavily flag the centerline location, particularly in difficult terrain.
- Avoid laying a trail out on flat terrain because water has no place to drain.
- Use a soil spade to investigate subsurface soil and moisture conditions along the route, especially near wetlands and in Alaska, generally.
- Large trees often have natural benches on their uphill side. It's better to locate your trail there rather than on the downhill side where you will sever root systems and generally undermine the tree. Your trail design specifications will tell you how close the trail can be to the tree.
- Look for natural platforms or terrain breaks for turn locations. They save construction costs and better fit the trail to the land.
- Double-flag locations for grade reversals or rolling grade dips.
- Look for small swales to locate grade reversals. The trail should climb gently for 10 to 12 feet on each side of the swale.
- Cross ravines at an angle rather than going straight up and down the ravine banks.
- Look for indications of shallow bedrock, such as patches of sparse vegetation.

—Adapted for OHV trails from the "Trail Construction and Maintenance Notebook" (Hesselbarth and others 2007).

Using GPS During Final Layout

Recreation- or mapping-grade GPS units are helpful when laying out trails. A preliminary trail alignment, entered into the device as a GPS route, can be used to navigate along the proposed alignment when the GPS unit is taken into the field. Minor control points can be entered and labeled as GPS waypoints for transfer to the project base map. Some examples are good crossings for streams and ridgelines and locations for climbing turns.

Once field investigations have been completed, the final proposed alignment can be mapped in the field as a GPS track and transferred to a topographic base map. This final alignment map can be used for environmental compliance review and permitting.

Figure 12–13—Blazes on trees can be used to supplement flagging to provide a more durable long-term delineation of the layout. Blazes should only be used for the final alignment marking.

Flagging and Clearing

Often a variety of colored ribbon flags or pin flags are placed along the alignment during field work (figure 12–12). Specific colors or types of flagging may identify different features and trail alignment alternatives. Once the final proposed alignment has been identified, all extraneous flagging should be removed and a single color and type of flagging should identify the centerline. The alignment also can be marked with painted blazes on trees (figure 12–13), wooden stakes or lath, and distance stations.

Figure 12–12—Surveyor's flagging is hung at the eye level of the person using the clinometer during trail layout.

More durable markings should be used when there might be a long delay between flagging and construction. A continuous flagging line should be visible when traveling from either direction along the alignment. A detailed trail log that includes distance stations and construction notes should be prepared. Double flags should be used to identify the lowest point of grade reversals and other water control features along the alignment. These flags will prevent relatively small, but critical, alignment details from being missed during construction.

Extensive clearing of the alignment should await completion of the environmental compliance process. Unforeseen environmental values discovered during field reviews may force alignment modifications. It's a good idea to clear a foot path, if necessary, to make it easier to walk along the alignment. The path will help during field work and will provide easy access for crews.

Major and Minor Rerouting Along Existing Alignments

Rerouting a portion of a trail can:

- Eliminate fall-line alignments
- Reduce grades on trail segments that are too steep
- Provide a better alignment to avoid degraded segments or poor quality sites
- Modify the flow and character of trail alignments

The trail condition assessment is the primary reference when determining areas where trails may need to be rerouted. Examples of areas that might benefit from rerouting include:

- Trail segments with grades steeper than 10 percent
- Grades too steep for the surrounding sideslope
- Degraded trail segments that are too wide, braided, or entrenched
- Trail segments with unsuitable soils or poor drainage, extreme surface muddiness, or ruts deeper than 9 inches

These segments would be listed as degraded in the condition class ranking system described in "Element 5—Trail Condition Assessment."

Proposed reroutes should be compared to the cost and long-term benefits of implementing use controls, increasing maintenance or project-level mitigation, or closing the trail. These options were discussed in "Element 6—Evaluation of Management Options." This evaluation, which should be made for individual trail segments, depends on an agency's capabilities, the adjacent site conditions, and logistic issues. Major reroutes require the same careful layout as new trails.

Prescriptions—Existing Trails

Prescriptions for existing alignments can be made using wheel and clipboard inventories, electronic data recorders, and GPS-supported inventories.

Forest Service TRACS

The Forest Service TRACS system is designed to provide useful data for trail program planning and management at all levels of the agency. TRACS field data are recorded in INFRA, a Forest Service corporate database, where they are used for the national trail system inventory, reporting deferred maintenance, planning capital investments, and planning for trail maintenance and management.

TRACS includes field inventory, condition assessment, and site-specific prescriptions. Ideally, these tasks are completed during one survey—the basis for the slogan "Collect the right information the first time." This may or may not always be possible, depending on trail-specific conditions and the availability of trained personnel.

In many situations, TRACS inventory, assessment, and prescriptions may need to be completed in phases, pending the availability of management direction, missing information, additional resources, or technical expertise. TRACS field data can be recorded on paper forms or with an electronic data recorder called "eTRACS." The eTRACS recorder automatically collects milepost data with an electronic distance measuring instrument and can be used with a GPS receiver.

Forest Service TRACS surveys must be conducted by adequately trained and experienced personnel with local field knowledge. TRACS surveyors must:

- Fully understand the trail management objectives (TMO) for a given trail
- Be able to recognize whether the trail meets agency standards
- Develop an effective and reasonable prescription for the trail if the trail does not meet agency standards

TRACS surveys are conducted with sustainable trail design concepts in mind. Trail expertise is needed to evaluate maintenance, resource, or other issues identified during TRACS surveys. Sustainable trail design guidelines, use controls, or other management options can be applied to mitigate issues identified during a TRACS survey.

TRACS includes the following components:

- **Trail Management Objectives (TMO)—**The establishment of a draft or final trail management objective for each trail with defined trail uses, trail class, and design parameters (see "Element 3—Trail Management Objectives").
- **Condition Assessment Survey Matrix (CASM)—**A guide for determining trail condition survey methods based on trail class assignments. The matrix provides recommended minimums for data accuracy and specificity (figure 12–14). A TRACS survey on a class 4 trail requires greater accuracy and more specificity than a TRACS survey on a class 2 trail.
- **TRACS data dictionary—**The "Trails Data Dictionary" of trail features and tasks, including standardized drawings, units of measure, and task severity factors. The data dictionary is available on the Forest Service's internal computer network at http://fsweb.wo.fs.fed.us/rhwr/ibsc/tr-data-dictionary.shtml.
- **TRACS survey forms—**Standardized paper and electronic forms for data collection. Electronic forms are available on the Forest Service's internal computer network at http://fsweb.wo.fs.fed.us/rhwr/ibsc/tr-tracs.shtml.
- **Supplemental field data—**Site productivity factors, sign inventories, photo records, and trail bridge inventories and inspections.
- **Application of field data—**TRACS field data are incorporated into INFRA, where they can be accessed for trail program management, planning, and reporting.

CASM

Trail Condition Assessment Survey Matrix

A Guide to Recommended Survey Methods and Accuracies

4/27/2005

CASM is the Forest Service's guide for conducting efficient and appropriate trail inventory and condition surveys, based on the on the level of trail development or Trail Class, investment in trail structures, and visitor expectations. CASM values are recommended minimums for data accuracy and specificity. Local managers may select more rigorous frequencies, methods, or accuracies as determined necessary.

Assessment Factors	Trail Class 1	Trail Class 2	Trail Class 3	Trail Class 4	Trail Class 5
Survey Method [1]	Walk-through & Make Notes on Map or GPS [2]	Cyclometer or GPS [2]	Cyclometer or GPS [2]	Cyclometer	Tape or Cyclometer & Hand Level with Digital Readout
Recommended Survey Accuracy & Specificity					
Measurement Interval [3]	Major Physiographic Changes	Minor Physiographic Changes or ½ Mile	Typical Grade Changes of 10% or 500 Feet	Typical Grade Changes of 10% or 500 Feet	Inter-visible Alignment Changes, 2% Grade Changes, or 25 Feet
Typical Grade [4]	+/- 10%	+/- 10%	+/- 5%	+/- 5%	+/- 1%
Typical Width [5]	Not Measured	Optional +/- 6"	+/- 6"	+/- 6"	+/- 3"
Obstacles [6]	Not Measured	Not Measured	Optional	Formidable Obstacles (e.g. narrow width with steep drop off)	All those defined as Obstacles
Typical Cross Slope [7]	Not Measured	Not Measured	+/- 1%	+/- 1%	+/- 0.1%
Features & Tasks [8]	Maximum Grouping of Features & Tasks	Grouping of Features & Tasks	Grouping of Features & Tasks Optional	Each Feature & Task Inventoried & Assessed Individually	Each Feature & Task Inventoried & Assessed Individually

[1] Survey Method: Most efficient method that accomplishes identified CASM accuracies.

[2] GPS: TRACS data collected via GPS must meet agency GIS spatial standards. This usually includes differential correction and editing for multi-pathing, spiking, and degraded satellite coverage.

[3] Measurement Interval: Maximum interval between collecting a full set of survey points for Typical Grade, Typical Width, Obstacles, Typical Cross Slope, and applicable Features and Tasks. If an element (i.e. Typical Grade) changes more frequently than the maximum interval, record those changes based on the CASM accuracy identified for that element.

[4] Typical Grade: Initiate new survey segment when Typical Grade changes by this amount.

[5] Typical Width: Initiate new survey segment when Typical Width changes by this amount.

[6] Obstacles: For those defined (see FSM/FSH, Infra Business Rules, Universal Access guidelines, etc.)

[7] Typical Cross Slope: Accuracy of Rise-over-Run measurement across Typical Tread Width.

[8] Grouping Features & Tasks: Features and Tasks can be grouped within survey segment.

Figure 12–14—"Trail Condition Assessment Survey Matrix" (CASM). —*From "TRACS: Trail Assessment & Condition Surveys 2008 User Guide" (U.S. Department of Agriculture, Forest Service 2008).*

Feature Types

The data dictionary divides constructed trail features and reference points into eight major feature types. These feature types are listed in table 12–5 with their abbreviated code and the number of features and subtypes in each category.

For each constructed feature, the data dictionary identifies whether it is a point or line feature, the required units of measure, the corresponding standard drawing, and primary material types.

Within each feature type, several standardized features are identified. For example, trailside structures (figure 12–15) are broken into seven features, including traffic counters (SS-CNT), registration box (SS-RBX), docks (SS-DOK), benches (SS-BNH), information boards (SS-INF), garbage containers (SS-GAR), and a place holder for a custom trailside structure that may be identified for a specific trail, forest, or region (SS-CUS). Each of these features is further divided into subtypes. For example, the data dictionary identifies two subtypes of information board: flat-panel information board (SS-INF-PAN) and information kiosk (SS-INF-KSK).

Table 12–5—TRACS data dictionary feature types. *—Adapted from "TRACS: Trail Assessment & Condition Surveys 2008 User Guide" (U.S. Department of Agriculture, Forest Service 2008).*

Feature type	Code	Number of features and subtypes
Trailway	TW	12 standardized features with 11 subtypes
Trail structures	TS	15 standardized features with 40 subtypes
Trail bridges	TB	1 standardized feature with 10 subtypes
Drainage structures	TD	9 standardized features with 20 subtypes
Trailside structures	SS	7 standardized features with 14 subtypes
Restrictive devices	RD	5 standardized features with 14 subtypes
Route markers and signs	RM	8 standardized features with 20 subtypes
Adjacent reference points	RP	3 standardized features with 19 subtypes

Feature / Tasks					Basic Inventory & Dimensions											Materials															
Feature / Task Code	Feature[1]	Line or Point Feature	Task UoM (Unit of Measure)	Standard Drawing	BMP: mi, ft (km, m)	EMP: mi, ft (km, m)	Quantity: ea	Length: ft (m)	Width in (mm)	Depth: in (mm)	Height: in (mm)	Radius: ft (m)	Diameter: in (mm)	Material Type (primary)	Distance to Material Source or Nearest Trailhead: ft (m)	Rock	Native Log	Treated Log	Native Sawn Wood	Treated Sawn Wood	Metal	Concrete	Composites	Plastic or Rubber	Native Soil	Select Borrow	Aggregate	Asphalt	Chunk Wood	Clay	Other (or unknown)
TRAILSIDE STRUCTURES																															
SS-CNT	**TRAFFIC COUNTERS**	P																													
SS-CNT-BRD	Buried Counter	P	EA	*(needed)*	R		R[1]								R						•										•
SS-CNT-TRE	Tree-Mounted Counter	P	EA	*(needed)*			R[1]								R						•										•
SS-RBX	**REGISTRATION BOX**	P																													
SS-RBX-RBG	Ground-Mounted Registration Box	P	EA	*(needed)*	R		R[1]							R	R				•	•	•			•							•
SS-RBX-RBE	Post-Mounted Registration Box	P	EA	*(needed)*			R[1]							R	R				•	•	•			•							•
SS-DOK	**DOCKS**	P																													
SS-DOK-STA	Stationary Dock	P	SF	*(needed)*	R		R[1]	**R**	**R**		O			R	R		•	•	•	•	•	•									•
SS-DOK-FLT	Floating Dock (simple)	P	SF	*(needed)*			R[1]	**R**	**R**		O			R	R		•	•	•	•	•	•									•
SS-BNH	**BENCHES**	P																													
SS-BNH-PRM	Primitive Bench	P	EA	*(needed)*	R	R+	R+	O	O		O			R	R	•	•	•	•	•	•	•	•	•							•
SS-BNH-MNF	Manufactured Bench	P	EA	*(needed)*		R+	R+	O	O		O			R	R	•	•	•	•	•	•	•	•	•							•
SS-INF	**INFORMATION BOARD**	P																													
SS-INF-PAN	Flat-Panel Information Board	P	SF	*(needed)*	R		R[1]		**R**		**R**			R	R		•		•	•	•		•								•
SS-INF-KSK	Information Kiosk	P	SF	*(needed)*			R[1]		**R**		**R**			R	R	•	•	•	•	•	•		•								•
SS-GAR	**Garbage Containers**																														
SS-GAR-CAN	Residential-Style Garbage Can	P	EA	*(needed)*	R		R[1]	R	R					R	R	•	•	•	•	•	•	•	•	•							•
SS-GAR-BIN	Commercial Bin	P	EA	*(needed)*			R[1]	R	**R**					R	R	•	•	•	•	•	•	h	•	h							•
SS-CUS	**CUSTOM TRAILSIDE STRUCTURE**	L / P																													
SS-CUS-SS1	Custom Trailside Structure 1	P	EA		R		R[1]	R	R					R	R	•	•	•	•	•	•	•	•	•							•
SS-CUS-SS2	Custom Trailside Structure 2	L	LF		R	O	R[1]	**R**	O					R	R	•	•	•	•	•	•	•	•	•							•

Figure 12–15—"TRACS Data Dictionary: Features and Tasks Spreadsheet." An excerpt that includes the feature/task codes, features, basic inventory and dimensions, and materials list for trailside structures. There is a similar list for the other seven feature types. *—From "TRACS: Trail Assessment & Condition Surveys 2008 User Guide" (U.S. Department of Agriculture, Forest Service 2008).*

Condition Codes

In addition to feature identification, the TRACS data dictionary incorporates seven basic feature condition codes describing required actions to meet trail standards. The condition codes are subdivided into three maintenance categories: annual, deferred, and capital improvement.

Annual Maintenance

Condition code 1—Routine maintenance. The feature is functioning within its design standard as designed and is within normal maintenance cycle (generally at a cost of less than 20 percent of replacement).

Deferred Maintenance

Condition code 2—Repair/rehabilitate. The feature may or may not be usable, but needs to be repaired to bring the feature up to standard (generally at a cost of between 21 and 50 percent of replacement).

Condition code 3—Replace in kind. The feature is beyond its life cycle or generally is unable to perform as designed or constructed (generally replacement, including demolition and removal of the existing feature, costs more than 51 percent of new construction).

Condition code 4—Decommission. The feature is not needed for operation of the trail or is inappropriate for the setting and should be removed from the system with no replacement planned.

Capital Improvement

Condition code 5—Expansion. The feature is basically functioning as designed but is undersized. The feature typically would be lengthened or widened, but in some cases size may be reduced.

Condition code 6—Alter function. The feature would be modified to change function to increase capacity, change function, or change durability.

Condition code 7—Install new. A new feature is needed.

Feature condition codes can be recorded separately for each feature during a TRACS survey or can be recorded while coding tasks.

Task Codes

Tasks identify the specific maintenance or improvement action needed to meet the trail design specifications. For every feature, the TRACS data dictionary identifies a series of corresponding tasks. On the TRACS survey form, tasks can be written out or annotated using an abbreviated task code that integrates the condition codes. For example, the data dictionary (figure 12–16) identifies 19 standardized tasks for the tread and prism feature.

Feature / Tasks					Severity 1	Severity 2	Severity 3	Severity 4	Severity 5
Feature / Task Code	Feature[1] / Task Description	Line or Point Feature	Task UoM (Unit of Measure)	Condition Class	Description	Description	Description	Description	Description
TW-TRD	TREAD & PRISM	L	SF						
TW-TRD-01a	Routine Tread Maintenance		Mi	Annual Mtce	AutoCalculated				
TW-TRD-01b	Routine Tread Drainage		Mi	Annual Mtce	AutoCalculated				
TW-TRD-01c	Snow Grooming - Large Dual-Track class		Mi	Annual Mtce	6-8 mph	4-6 mph	2-4 mph	< 2 mph	
TW-TRD-01d	Snow Grooming -Track-Setting with Snowmobile		Mi	Annual Mtce	15-20 mph	10-15 mph	5-10 mph		
TW-TRD-02a	Reestablish original native tread		LF	Repair	Recut < 10% of original prism dimensions	Recut between 10 & 25% of original prism	Recut between 25 & 50% of original prism	Recut between 50 & 100% of original prism	Recut 100% of original prism
			MI	Repair	Recut < 10% of original prism dimensions	Recut between 10 & 25% of original prism	Recut between 25 & 50% of original prism	Recut between 50 & 100% of original prism	Recut 100% of original prism
TW-TRD-02b	Stump removal		EA	Repair	Less than 6-in diameter	Between 6-in and 12-in diameter	Between 12-in and 24-in diameter	Between 24-in and 48-in diameter	Over 48-in diameter
			Mi	Repair	1-3 per mile	3-5 per mile	5-10 per mile	Over 10 per mile	
TW-TRD-02c	Flatten steep backslope		LF	Repair	Flatten by an additional 1/4:1	by 1/2:1	by 3/4:1		
TW-TRD-02d	Repair trenched tread		LF	Repair	Cut slope edges	Combo: slope edges & borrow	Fill with borrow		
TW-TRD-02e	Recompact native tread		LF	Repair	3-pass Machine Compaction	T-99 Spec Compaction			
TW-TRD-02f	Add Soil Ammendment/Stabilizers		SY	Repair	Generic Type				
TW-TRD-02g	Major slide/slump excavation		LF	Repair	Debris composed primarily of soil	Debris composed of soil and rock	Debris composed of soil, rock, stumps, and logs		
TW-TRD-02h	Import and place top soil		SF	Repair	1/2-in deep	1-in deep	2-in deep		
TW-TRD-02i	Berm Removal		LF	Repair	<12-in above tread in	<12-in above tread in	>15-in above tread in	>15-in above tread in	

Figure 12–16—"TRACS Data Dictionary: Tasks." An excerpt that includes some of the feature/task codes, feature/task descriptions, and condition classes and severity descriptions for the tread and prism feature. There is a similar list for the other seven feature types. *—From "TRACS: Trail Assessment & Condition Surveys 2008 User Guide" (U.S. Department of Agriculture, Forest Service 2008).*

Severity Factors

The data dictionary includes one or more severity factors for each task. For example, the task “TW-TRD-02h—Import and place top soil” includes three severity factors:

1. ½-inch thick soil placement
2. 1-inch deep soil placement
3. 2-inch deep soil placement

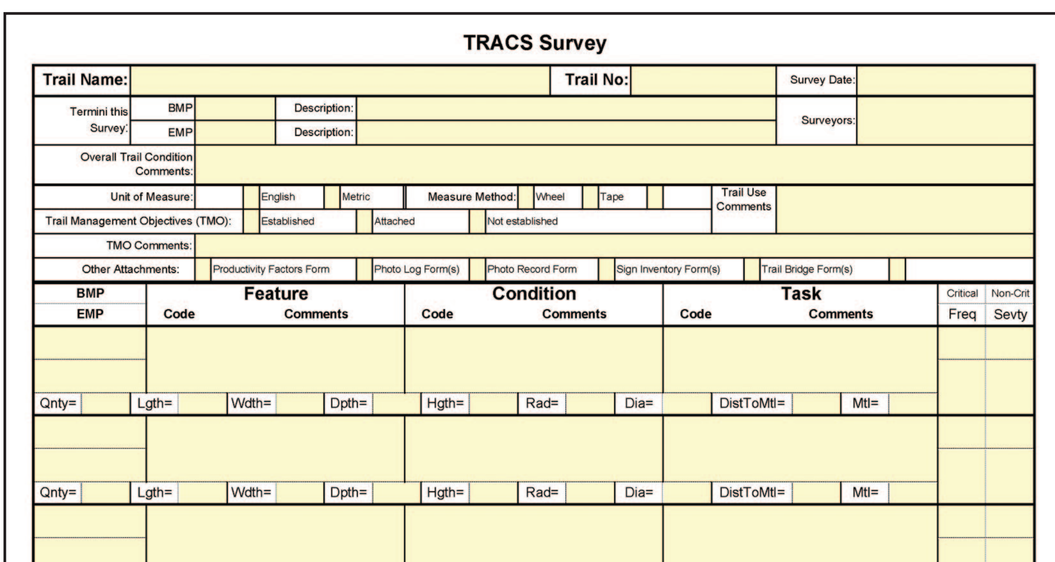
These severity factors rank increasing cost or workload complexity from 1 to 3.

TRACS Survey Form

An important part of a TRACS survey is determining whether the trail complies with TMO-specified design parameters, and if not, determining what is needed to bring the trail into compliance. Standardized paper or electronic TRACS survey forms have blocks to document existing trail features, describe their condition, and identify specific maintenance or improvement tasks needed to meet trail standards. Figure 12–17 shows a portion of the form. The complete form is in appendix E and is available on the Forest Service’s internal computer network at http://fsweb.wo.fs.fed.us/rhwr/ibsc/tr-tracs.shtml.

In addition to the features, condition codes, and tasks identified in the data dictionary, the TRACS form includes space to indicate the priority and frequency for each task. A critical priority addresses a serious threat to public health or safety, a natural resource, or the ability to carry out the organization’s mission. A noncritical priority addresses potential risk to the public or employee safety or health; compliance with codes, standards, regulations; or needs that address potential adverse consequences to natural resources or mission accomplishment. A check mark or “X” in the appropriate block indicates the task’s priority. Task frequency is the number of times each year that routine or recurring tasks should be accomplished to meet the standard. Once a year is denoted as 1, twice a year as 2, once every 2 years as 0.5, and so forth.

Depending on the surveyor’s preference, the feature, condition, and task prescriptions can be recorded on TRACS survey forms using the full description or the abbreviated feature and task codes. Often, a single task code captures all three pieces of information. Surveyors are encouraged to make clarifying narrative comments and provide additional detail during the field survey. These comments can become valuable references for data editing and project planning. The TRACS survey form is not meant to be a rigid format for field data collection. It can be adapted or modified as desired.



TRACS Survey

Trail Name: | Trail No: | Survey Date:
Termini this Survey: BMP | Description: | EMP | Description: | Surveyors:
Overall Trail Condition Comments:
Unit of Measure: English | Metric | Measure Method: Wheel | Tape | Trail Use Comments
Trail Management Objectives (TMO): Established | Attached | Not established
TMO Comments:
Other Attachments: Productivity Factors Form | Photo Log Form(s) | Photo Record Form | Sign Inventory Form(s) | Trail Bridge Form(s)

BMP / EMP	Feature Code	Feature Comments	Condition Code	Condition Comments	Task Code	Task Comments	Critical / Freq	Non-Crit / Sevty

Qnty= | Lgth= | Wdth= | Dpth= | Hgth= | Rad= | Dia= | DistToMtl= | Mtl=
Qnty= | Lgth= | Wdth= | Dpth= | Hgth= | Rad= | Dia= | DistToMtl= | Mtl=

Figure 12–17—“TRACS Survey” form. *—From “TRACS: Trail Assessment & Condition Surveys 2008 User Guide” (U.S. Department of Agriculture, Forest Service 2008).*

Supplemental Field Data

The Forest Service also has identified several categories of supplemental field data that can be collected during TRACS surveys. These include sign inventories, prescriptions, trail bridge inventories, inspections, photo logs, and productivity factors. With the exception of productivity factors, these supplemental data will not be discussed in any detail here. See the TRACS Web site on the Forest Service's internal computer network at http://fsweb.wo.fs.fed.us/rhwr/ibsc/tr-tracs.shtml for additional information on sign, bridge, and photo data collection.

Productivity Factors

Productivity factors are a key set of physical factors that affect the production rate, cost of trail construction, and maintenance. The productivity factors are:

- Typical trail grade
- Typical sideslope
- Typical soil type
- Typical vegetation (brush and regeneration)
- Typical vegetation (timber)

Productivity factors can be inventoried separately, during a TRACS survey, or when documenting the trail location (see "Element 4—Documentation of Trail Location"). Productivity factor surveys generally do not need to be updated unless there is change in field conditions (such as reconstruction) affecting trail grade or rerouting.

Productivity factor data are used for planning trail construction and maintenance and for refining trail cost data in the Forest Service INFRA database. INFRA has a default value (displayed in bold in the "TRACS Productivity Factor Codes" list in appendix J) identified for each productivity factor. A cost estimate based on that default value is assigned a cost and productivity rate coefficient of "1." A coefficient has been calculated for each value above or below the default. For example, the cost and production rate to construct new trail through heavy brush is about 2.5 times higher than through light brush. Appendix J includes the` "OHV Trail Adjustment Factors" list adapted from Forest Service data for trail construction and maintenance. Although this list is not as detailed as the Forest Service database, the list may be adapted for estimating costs and project planning.

Application of Field Data

Trail managers can use TRACS survey data stored in INFRA to identify tasks and create specific work assignments for individual field crews. Tasks can be sorted so task assignments can be developed for unskilled volunteer crews separately from assignments for highly trained crews. A trail work list can be printed to help crews locate work areas, complete identified work, document task accomplishments, and note other work requirements. Completed trail work lists, compiled electronically or printed, provide managers with a record of annual trail work accomplishments and supplemental field notes. These lists can be used to update task assignments, make annual reports, or plan future work and budget requests.

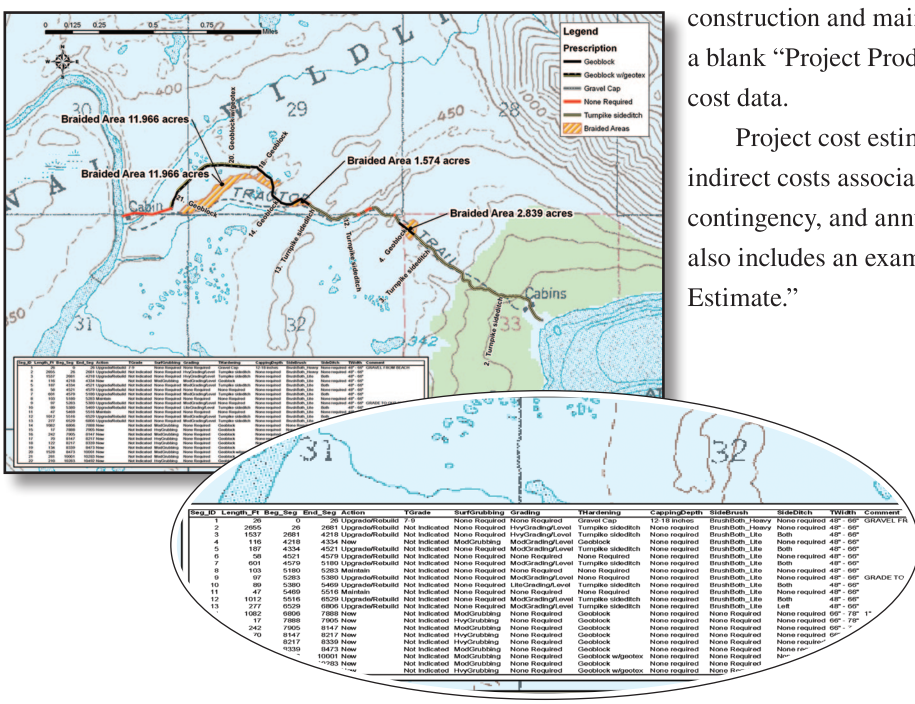
TRACS is an effective approach to trail inventory, condition assessment, and prescription that is well documented and that can be adapted by any OHV trail manager. If well-developed trails have draft or final TMOs, the TRACS approach is recommended for maintenance prescriptions. Documentation, training materials, and standard forms are on the Forest Service's internal computer network at http://fsweb.wo.fs.fed.us/rhwr/ibsc/tr-tracs.shtml. Standard trail specifications and drawings are on the Internet at http://www.fs.fed.us/.ftproot/pub/acad/dev/trails/trail.htm.

Alaska NPS OHV Trail Prescription Process

Typically, NPS trail specialists conduct a condition assessment of a trail on the outgoing leg of a trail traverse and develop a prescription on the return. The outgoing leg provides the opportunity to observe and document trail conditions, develop an understanding of what is causing the degradation, and get ideas about the mitigation and maintenance actions that might be needed. Prescription actions are identified and documented on the return leg using a data dictionary.

The NPS Alaska Region used the principles as described in "Element 5—Trail Condition Assessment," to develop a GPS-based data dictionary. The "Alaska NPS OHV Trail Prescription GPS Data Dictionary" (Alaska NPS data dictionary) works particularly well in less well-developed or remote trail systems.

The Alaska NPS data dictionary can be used for manual mapping without a sophisticated GPS unit that records attributes. Figure 12–18 shows the data collected during mapping (lower left corner). Appendix E includes the "Prescription Manual Data Sheet" and the "Prescription Codes." The data sheet provides space to enter waypoint numbers when using a recreation-grade GPS unit.



Seg_ID	Length_Ft	Beg_Seg	End_Seg	Action	TGrade	SurfGrubbing	Grading	THardening	CappingDepth	SideBrush	SideDitch	TWidth	Comment
1	26	0	26	Upgrade/Rebuild	7-9	None Required	None Required	Gravel Cap	12-18 inches	BrushBoth_Heavy	None required	48" - 66"	GRAVEL FR
2	2655	26	2681	Upgrade/Rebuild	Not Indicated	None Required	HvyGrading/Level	Turnpike sideditch	None required	BrushBoth_Heavy	None required	48" - 66"	
3	1537	2681	4218	Upgrade/Rebuild	Not Indicated	None Required	HvyGrading/Level	Turnpike sideditch	None required	BrushBoth_Lite	Both	48" - 66"	
4	116	4218	4334	New	Not Indicated	ModGrubbing	ModGrading/Level	Geoblock	None required	BrushBoth_Lite	None required	48" - 66"	
5	187	4334	4521	Upgrade/Rebuild	Not Indicated	None Required	ModGrading/Level	Turnpike sideditch	None required	BrushBoth_Lite	Both	48" - 66"	
6	58	4521	4579	Upgrade/Rebuild	Not Indicated	None Required	None Required	None Required	None required	BrushBoth_Lite	None required	48" - 66"	
7	601	4579	5180	Upgrade/Rebuild	Not Indicated	None Required	ModGrading/Level	Turnpike sideditch	None required	BrushBoth_Lite	Both	48" - 66"	
8	103	5180	5283	Maintain	Not Indicated	None Required	None Required	None Required	None required	BrushBoth_Lite	None required	48" - 66"	
9	97	5283	5380	Upgrade/Rebuild	Not Indicated	None Required	ModGrading/Level	None Required	None required	BrushBoth_Lite	None required	48" - 66"	GRADE TO
10	89	5380	5469	Upgrade/Rebuild	Not Indicated	None Required	LiteGrading/Level	Turnpike sideditch	None required	BrushBoth_Lite	Both	48" - 66"	
11	47	5469	5516	Maintain	Not Indicated	None Required	None Required	None Required	None required	BrushBoth_Lite	None required	48" - 66"	
12	1012	5516	6529	Upgrade/Rebuild	Not Indicated	None Required	ModGrading/Level	Turnpike sideditch	None required	BrushBoth_Lite	Both	48" - 66"	
13	277	6529	6806	Upgrade/Rebuild	Not Indicated	None Required	ModGrading/Level	Turnpike sideditch	None required	BrushBoth_Lite	Left	48" - 66"	
	1082	6806	7888	New	Not Indicated	ModGrubbing	None Required	Geoblock	None required	None Required	None required	66" - 78"	1"
	17	7888	7905	New	Not Indicated	HvyGrubbing	None Required	Geoblock	None required	None Required	None required	66" - 78"	
	242	7905	8147	New	Not Indicated	ModGrubbing	None Required	Geoblock	None required	None Required	None required		
	70	8147	8217	New	Not Indicated	HvyGrubbing	None Required	Geoblock	None required	None Required	None required		
		8217	8339	New	Not Indicated	HvyGrubbing	None Required	Geoblock	None required	None Required			
		8339	8473	New	Not Indicated	ModGrubbing	None Required	Geoblock	None required	None Required			
			10001	New	Not Indicated	ModGrubbing	None Required	Geoblock w/geotex	None required	None Required			
			[illegible]	New	Not Indicated	ModGrubbing	None Required	Geoblock	None required	None Required			
				[illegible]	Not Indicated	HvyGrubbing	None Required	Geoblock w/geotex	None required				

Figure 12–18—An OHV trail prescription map with manual data sheet (lower left corner).

Appendix F includes the complete "Alaska NPS OHV Trail Prescription GPS Data Dictionary." This data dictionary helps managers identify major maintenance needs for tread and support structures.

Estimated Costs and Labor Requirements for Trail Prescriptions

Estimating costs and labor requirements is an important part of the trail prescription. These estimates provide the basis of funding and budget requests and for any cost/benefit analysis conducted for a project.

The cost of a project and the amount of labor needed to complete the work depend on local conditions, methods used, and the difficulty of the task. Some OHV trail managers may be lucky enough to have well-developed cost systems. Forest Service TRACS, for example, includes integrated software that provides cost estimates, which trail managers can refine. Some trail managers have inherited detailed cost and labor estimate data from previous OHV trail managers or they may be able to adapt data from other types of trail construction. Other trail builders also may be willing to share their estimates. Because these data are so valuable, do not be too proud to beg.

Some trail managers will have to develop cost estimates from scratch, diligently tracking the cost of each construction and maintenance project. See appendix E for a blank "Project Production Log" to record production and cost data.

Project cost estimates should include all direct and indirect costs associated with a project and overhead, contingency, and annual cost adjustments. Appendix E also includes an example of a project "Prescription Cost Estimate."

Alaska NPS Data Dictionary Attributes and Values

The prescription feature TRAILWAY (GPS format for "trailway") includes 16 prescription attributes:

ACTION (Action)	TGRADE (Trail grade)	SURFGRUB (Surface grubbing)
GRADING (Grading)	THARDENING (Trail hardening)	CAPPING (Capping depth)
SUBBASE (Subbase)	CLEARING (Clearing)	SIDEBRUSH (Sidebrush)
SIDEDITCH (Sideditch)	WATERMGT (Water management)	CUTFILLSEC (Cut/fill segment)
REHAB (Rehabilitation)	TWIDTH (Trail width)	NAME (Name)
COMMENT (Comment)		

Each prescription attribute has a list of values the user can select. For example, the values for the ACTION, SIDEDITCH, and REHAB prescription attributes are:

ACTION	SIDEDITCH	REHAB
New	None required	None required
Maintain	Maintain left	Scarify
Upgrade/rebuild	Maintain right	Reseed
Narrow/reduce	Maintain both	Rehabilitate
Widen/enlarge	New left	
Abandon	New right	
Close/barricade	New both	
Rehabilitate		
Other		

The Alaska NPS Data Dictionary (appendix F) includes additional information for:

- Line attributes for bridges
- Point attributes for anchor point, aqua management, stream crossing, development, physical reference point, photopoint, hazard, control point, signs, and trailside structures
- Area attributes for braids and parking areas

Tasks That Should Have a Cost Estimate

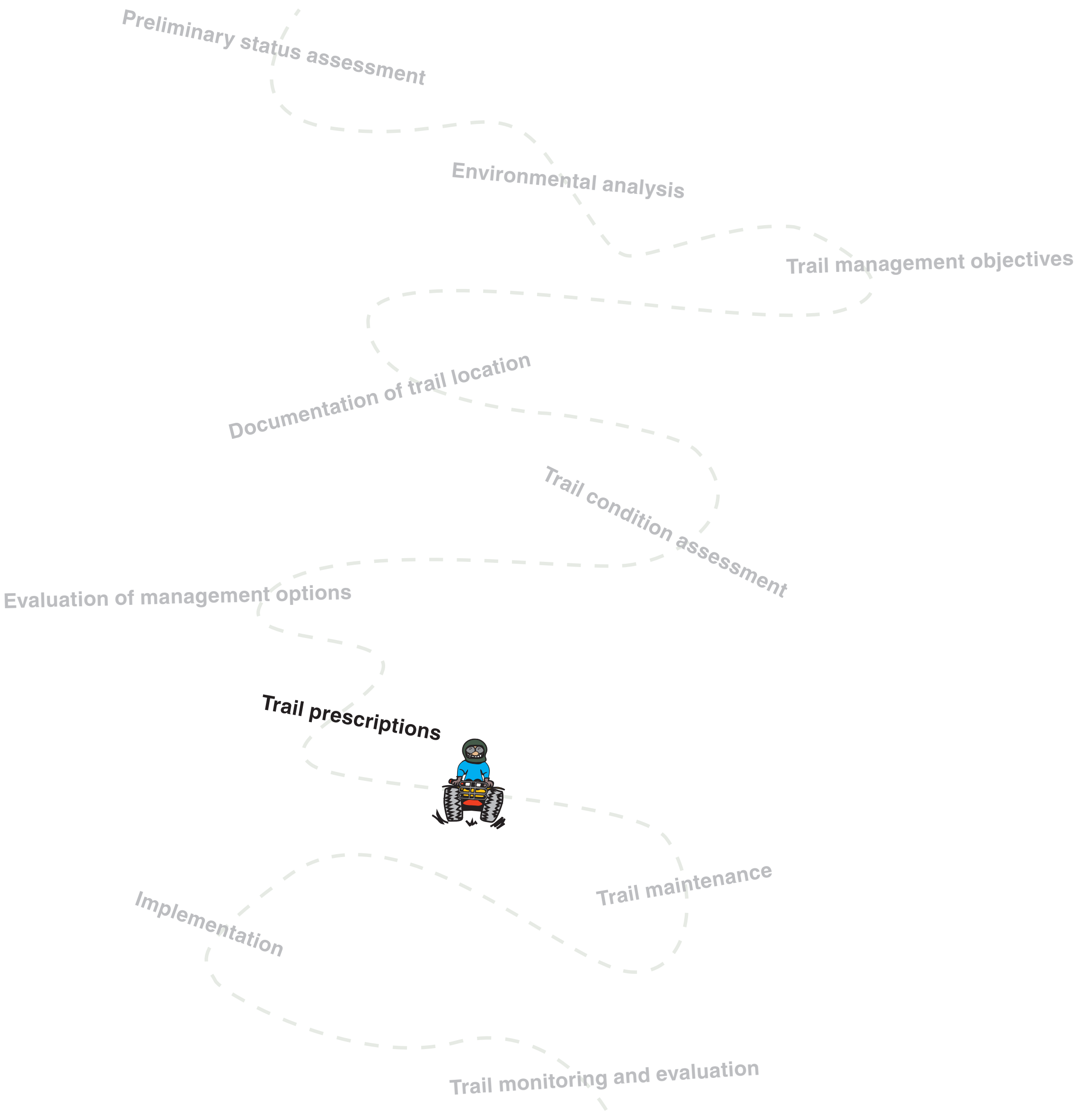
A list of the major tasks that should have a cost estimate include:

- Project planning
- Prescription development
    - Existing trails
        - Condition assessments
        - Prescription preparation
            - Tread and structures evaluation
            - Rerouting evaluation
            - Rehabilitation potential
    - New trails
        - Trail corridor research
        - Layout and initial flagging
        - Design and construction specification
            - Engineering review
        - Construction method determination
- Compliance review (NEPA, EA, or EIS)
    - Office review
    - Field investigation
    - Document preparation
- Permitting
    - Permit research
    - Application submission
    - Permit fees
    - Permit administration
- Clearing
    - Mobilization and demobilization
    - Direct clearing
        - Crew labor
        - Equipment
        - Fuel and supplies
    - Associated crew support
        - Transportation
        - Per diem
        - Potential lodging or base camp
    - Field inspection and quality control
    - Reflagging
- Construction
    - Mobilization and demobilization
    - Tread construction
        - Equipment
        - Supplies and materials
        - Labor
    - Structure construction
        - Equipment
        - Materials
        - Labor
    - Support
        - Material transport, storage, handling
        - Associated crew support
            - Transportation
            - Per diem
            - Lodging or base camp
    - Field inspection and quality control
    - Maintenance or mitigation projects
    - Mobilization and demobilization
    - Equipment, materials, and supplies
    - Crew labor
    - Associated crew support
        - Transportation
        - Per diem
    - Reporting and documentation
- Monitoring
    - Mobilization and demobilization
    - Crew labor
    - Equipment, materials, and supplies
    - Associated crew support
        - Transportation
        - Per diem
    - Office analysis and documentation

Overhead costs may be assessed as a set percentage of total costs or may be assessed at several layers in the organization. They may include:

- An allowance for office supplies and motor pool
- Field inspections
- Clerical, procurement, budget, and contracting administration support

A contingency of 10 to 15 percent should be set aside to cover unforeseen expenses. An annual inflation adjustment may be needed if a project is scheduled several years into the future.


Preliminary status assessment
Environmental analysis
Trail management objectives
Documentation of trail location
Trail condition assessment
Evaluation of management options
Trail prescriptions
Implementation
Trail maintenance
Trail monitoring and evaluation

Draft

Chapter 13: Element 8—Trail Maintenance

Responding to maintenance issues has been one of the biggest concerns in OHV trail management. Trail maintenance helps return tread surfaces and trail structures to their original specifications, prolonging the utility of the trail and reducing environmental impacts. Maintenance includes identification of maintenance needs, allocation of resources, and the maintenance activities themselves.

Maintenance Scenarios

In general, there are two contexts for maintenance:

- Maintenance of trails designed and constructed specifically for OHVs
- Maintenance of trails informally developed by OHV users or adapted for OHVs

If a trail was designed and constructed for OHVs, the maintenance objective is to restore the trail to its original design specifications. If a trail does not have a TMO or set of design parameters, they should be developed before beginning trail maintenance.

Trails that were not designed or constructed for OHVs may require maintenance to address tread degradation, associated environmental impacts, and major trail design flaws. Maintenance needs can vary tremendously depending on use characteristics, environmental conditions, and character and location of the original trail alignment.

All OHV trails require regular scheduled maintenance, such as brushing, removal of material sloughing from backslopes, and repairs of trail structures. OHV trails may also require maintenance projects to regrade entrenched wheel tracks, center humps, or banked turns (figure 13–1).

Figure 13–1—OHV traffic on this cut-through climbing turn quickly forms wheel ruts and banked turns that can disrupt tread surface drainage. Regrading these to their original specifications is one of the primary purposes of OHV tread maintenance.

Determining Maintenance Needs

This report describes two methods to identify and document maintenance needs: the Forest Service TRACS and the Alaska NPS OHV trail prescription systems. Both were discussed in “Element 7—Trail Prescriptions.” Whichever method is used, trail prescriptions should be the primary reference for determining specific maintenance requirements.

The TRACS system applies to a wide range of trail situations and feeds directly into Forest Service trails planning and management systems. The Alaska NPS system works well when a trail prescription needs to be developed for poorly developed OHV trails. Both systems require technical knowledge of maintenance, sustainable design, and appropriate mitigation.

Types of Maintenance

General maintenance actions include:

- Season opening
- Tread, drainage, and trail structure repair
- Brushing
- Structure replacement and reconstruction
- Project-scale reconstruction, rerouting, or trail hardening projects

Season Opening

During season-opening maintenance, usually in the spring, crews cut out fallen trees that block trails, remove brush crushed by snow, open and clear culverts, clean drainage structures, sweep bridge decks, make minor repairs, and conduct quick inspections to identify more substantial maintenance needs.

Tread, Drainage, and Trail Structures

Regularly scheduled maintenance addresses problems with tread, drainage, and trail structures. The tread surface is reshaped by removing slough at the toe of the backslope, grading the tread to reestablish outslope, and compacting the tread surface. Reshaping removes the berms that have developed beside wheel tracks and encourages sheet flow across the bench. Supplemental gravel may be added and some minor trail hardening measures installed. Grade reversals, rolling grade dips, and other drainage features are reshaped and compacted. Drains, ditches, and culverts are cleared and cleaned. Puncheon, bridge decking, and handrails are inspected and repaired. Minor repairs may be made to retaining walls, bridge abutments, and other trail-related improvements.

Brushing

Brushing removes vegetation growing inside specified clearing limits along the trail. A crew equipped with loppers, brush cutting tools, weed whips, chain saws, mowers, or other power equipment traverses the trail and cuts and clears vegetation. Brushing may also be conducted as part of regularly scheduled maintenance.

The need for brushing varies, depending on the vegetation type and growing conditions. Some trails need to be brushed several times a year, while others only need to be brushed once a year or once every second or third year. Trails in desert settings and trails that cross alpine tundra may never require brushing.

Item (material)	Years
Bench (wood)	20
Bridge—abutment (rock)	40
Bridge—abutment (wood)	20
Bridge—footlog	10
Bridge—deck (wood)	20
Bridge—railing (wood)	20
Bridge superstructure (steel stringers)	50
Checks (rock)	45
Checks (wood)	20
Retaining wall (log)	20
Retaining wall (stone)	45
Culvert—closed (metal)	25
Culvert—closed (rock)	30
Culvert—open (rock)	30
Dip drain	5
Fencing/gates (concrete)	30
Fencing/gates (rock)	35
Fencing/gates (metal)	20
Fencing/gates (wood)	10
Handrail (cable)	3
Paved surface (asphalt)	20
Paved surface (concrete)	40
Puncheons	20
Retaining wall (rock)	40
Retaining wall (concrete)	50
Signage (concrete)	30
Signage (masonry/stone)	30
Signage (metal)	20
Signage (wood)	10
Steps (iron rung)	30
Trailhead kiosk	20
Turnpikes (wood)	20
Turnpikes (rock)	45
Waterbars (rock)	45
Waterbars (wood)	25

Figure 13–2—NPS life-cycle estimates for common trails equipment and features.

Structure Replacement and Reconstruction

All structures have a service life that depends on structure type, material, construction quality, weather, and impacts from use. Figure 13–2 is an NPS estimate of the service life of common trail equipment and features. Structures may be replaced or reconstructed during regularly scheduled maintenance or as a separate project, depending on how much work is required.

Project-Scale Reconstruction, Rerouting, and Trail Hardening

Significant changes to the trail or its physical or social environment require project-scale actions. These actions include projects to accommodate a change in use dictated by agency planning or a TMO. Major reconstruction or rerouting may also be needed because of major design flaws, overuse, neglect, significant degradation, or damage from extreme weather. Project-scale work may require detailed planning, environmental compliance, and permitting.

The Forest Service TRACS system divides maintenance into three types: annual maintenance, deferred maintenance, and capital improvement. Figure 13–3 displays the breakdown of maintenance types by condition codes. Annual maintenance would include season opening, routine brushing, and most related regularly scheduled maintenance. Deferred maintenance would include replacement, heavy repair, and reconstruction that will be needed in future years. Capital improvement would include new trail construction and trail alteration or expansion.

Condition Code	Condition Class	Condition Class Description	Annual Maintenance	Deferred Maintenance	Capital Improvement
1	**Routine Maintenance**	Feature is **functioning within standard** as designed and is within normal maintenance cycle (generally at a cost of less than 20% of replacement)	●		
2	**Repair/Rehab**	Feature is in **disrepair**, and may or may not be usable, but needs to be repaired to bring feature to standard (generally at a cost between 21% & 50% of replacement)		●	
3	**Replace in-kind**	Feature is **dysfunctional** and is beyond its designed lifecycle or generally has deteriorated to a point where unable to perform as designed or constructed (generally at a cost of over 51% of new construction and includes demolition and removal of existing)		●	
4	**Decommission**	Feature is **not needed** for the operation of the trail or is inappropriate for the setting and should be removed from system with no replacement planned.		●	
5	**Expansion**	Feature is basically functioning as designed but is **undersized**. Would typically be lengthened or widened, but in some cases size may be reduced.			●
6	**Alter Function**	Modify feature to **change function** to increase capacity, change function, or change durability.			●
7	**Install New**	**New feature** is needed.			●

Figure 13–3—TRACS Condition Codes. —*From "TRACS: Trail Assessment & Condition Surveys 2008 User Guide" (U.S. Department of Agriculture, Forest Service 2008).*

Maintenance Timing and Frequency

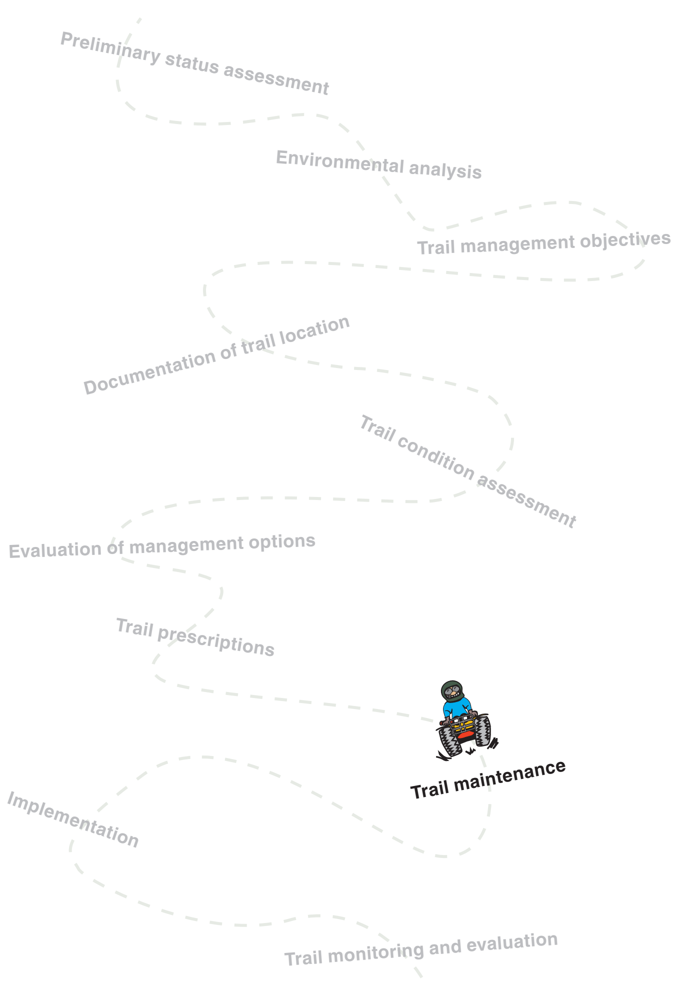
Season-opening maintenance should be done after the surface tread and subsoils are completely thawed and drain freely, often as late as mid June in northern latitudes.

Tread should be reshaped when soil moisture allows good surface compaction after grading. This is particularly important when constructing or maintaining drainage dips or reshaping the outslope.

To test for soil moisture, compact soil into a fist-sized ball. If the tread material won't compact into a ball without crumbling, the soil is too dry and soil particles won't bond properly. If the ball is muddy or water drains out, the tread material is too wet and water between the soil particles will prevent the material from compacting.

In some regions ideal soil moisture conditions occur seasonally. Try to schedule tread reshaping during those periods. Schedule work that does not require tread surface disturbance—such as sign maintenance, bridge deck replacement, trail hardening, brushing, and layout—when soil moisture is usually less than ideal. Keep a long list of projects that can be conducted under various weather conditions or season and be ready to redirect your crews.

The TMO form (figure 13–4) identifies the desired frequency of maintenance. Ideally, every trail would receive some maintenance each year. How often the work is done depends on funding, the number of employees available and their level of experience, the equipment available, overall trail conditions, and the number of trail miles requiring maintenance. Efficiency may be improved by using heavy equipment (such as a trail dozer) for tread grading, reshaping, and compaction.



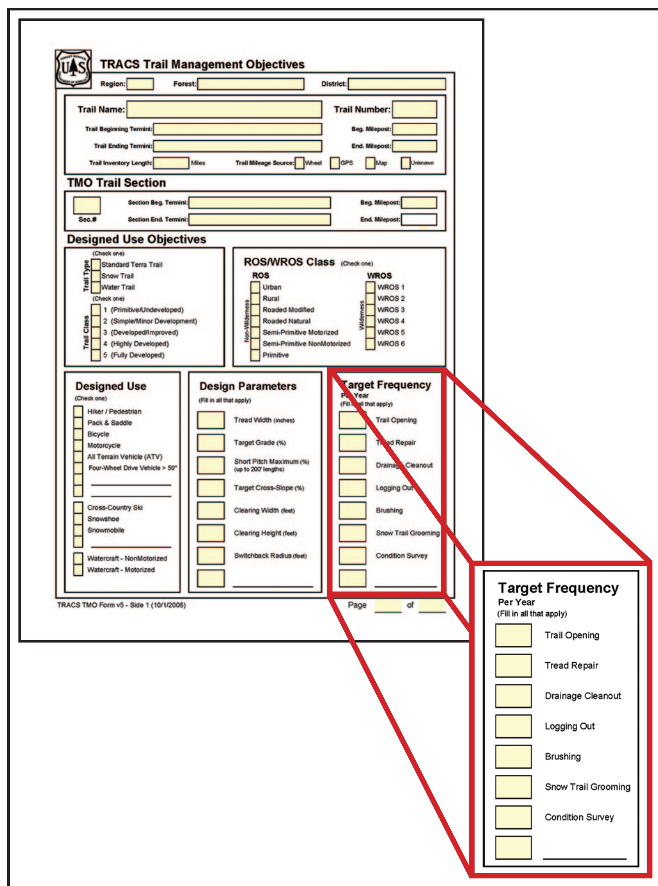


Figure 13–4—TRACS TMO target frequency.

Allocating Limited Maintenance Dollars

A familiar challenge within most trail organizations is having too few resources to complete all of the maintenance that is needed. Many agencies have developed a method for allocating funds (discussed later in this chapter).

The Forest Service allocates funds based on national quality standards. The NPS has developed an asset priority/facility condition index that guides allocation of funds (discussed later in this chapter).

Forest Service National Quality Standards

The Forest Service has identified national quality standards to guide maintenance. These standards outline the baseline level of service for trails.

Forest Service policies require immediate action (which may include closing the trail to public use) to correct or mitigate problems when trails do not meet critical national standards.

Forest Service National Quality Standards—Key Measures

Health and Cleanliness

- Visitors are not exposed to human waste along trails.
- The trail and trailside are free of litter.
- The trail and trailside are free of graffiti.

Resource Setting

- Effects from trail use do not conflict with environmental laws (**critical national standard**).
- Resource management adjacent to and along the trail corridor is consistent with Recreation Opportunity Spectrum objectives and the desired conditions of adjacent management areas.
- Trail opportunities, trail development, and trail management are consistent with Recreation Management System objectives and the forest land management plan.
- The trail, use of the trail, and trail maintenance do not cause unacceptable damage to other resources.
- Trail use does not exceed established trail capacity.

Safety and Security

- Hazards do not exist on or along the trail (**critical national standard**).
- Laws, regulations, and special orders are enforced.

Responsiveness

- When signed as accessible, the trail meets current agency policy and accessibility guidelines **(critical national standard).**
- Information is posted in a user friendly and professional manner.
- Visitors are provided opportunities to communicate expectations and satisfaction.

Condition of Facilities

- The trail and its structures are serviceable and in good repair throughout the designed service life (annual/routine maintenance).
- Trails in disrepair due to lack of scheduled maintenance, or in noncompliance with safety codes or other regulatory requirements, or beyond the designed service life are repaired, rehabilitated, replaced, or decommissioned (deferred maintenance).
- New, altered, or expanded trails meet Forest Service design standards and are consistent with Forest Service plan prescriptions (capital improvement).

National Park Service Asset Priority/Facility Condition Index

The NPS Facility Management Program has a process for allocating funds, the asset priority/facility condition index. This process determines the relative value of the asset and compares its relative value to its condition. The NPS system uses a series of attributes to help determine the value of its facility assets. These attributes include cultural significance, national significance, importance for visitor use, importance to park operations, and potential for substitution.

Each attribute is evaluated independently and assigned a total point value of 0, 5, 10, 15 or 20, depending on its relative importance. The sum of the assigned values produces a final ranking between 0 and 100 for each trail. A trail value index graph (figure 13–5) allows trails to be ranked as high, moderate, or low value.

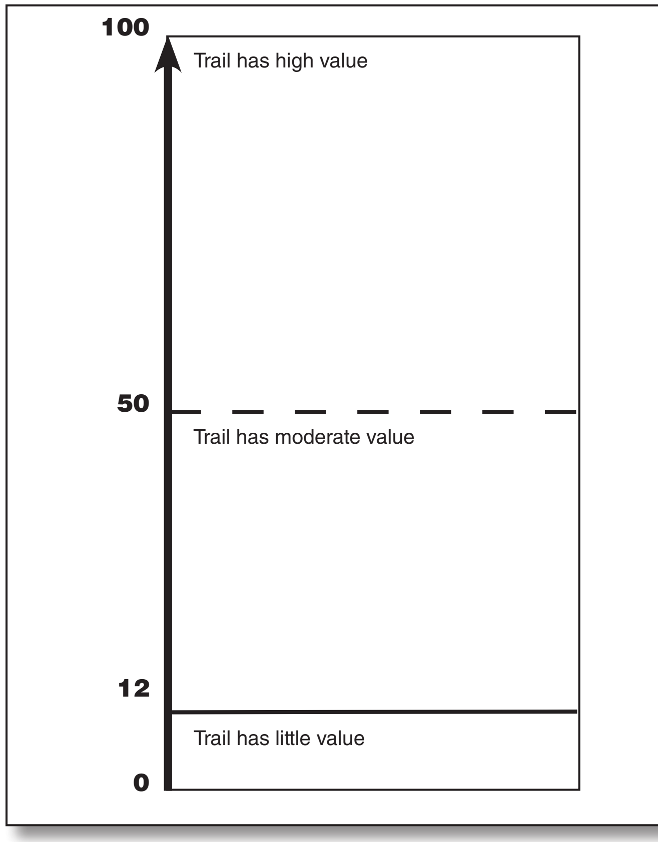


Figure 13–5—NPS trail value index.

National Park Service OHV Attribute Value List and Point Rankings

The NPS system for allocating funds could be adapted for OHV trails with this attribute list and point ranking:

1. Importance of the trail in accessing developed unit facilities.
   Critical (20 points)..One of many options (0 points)
2. Value of the trail in enhancing OHV user experience
   Highly valuable (15 points) ....Little contribution (0 points)
3. Historic/cultural/social significance of the trail
   National significance (5 points) .... No significance (0 points)
4. Quality of the trail design/layout
   Sustainable (20 points) ....Poor design (0 points)
5. Multiple-use value of the trail
   Heavy multiple use (10 points) ....No multiple use (0 points)
6. Availability of other OHV trails to provide alternative opportunities
   No other opportunities (20 points) ....Many opportunities (0 points)
7. Environmental/social compatibility of the trail
   No conflicts (10 points).......................................Many conflicts (0 points)

Trail Condition Index Values

The NPS facility condition index compares replacement values to projected cost of repairs. The facility condition index is calculated as:

$$\frac{DM + RMDM + CRDM + IPH}{\text{Current replacement value}}$$

Where:

DM = *Deferred maintenance costs*
RMDM = *Recurring deferred maintenance costs*
CRDM = *Component renewal deferred maintenance costs*
IPH = *Immediate personal hazard*

The NPS method is great if you are an employee with access to the agency's facility management computer system, adequate training, and data for the equation.

Another approach to developing a facility condition index would be to assign a relative condition value to the trail. This could be a purely subjective evaluation or one based on a systematic condition assessment (see "Element 5—Trail Condition Assessments").

The condition assessment evaluates the physical attributes of each trail segment, assigns a ranking weight to each attribute, and classifies each segment as good, fair, degraded, very degraded, or extremely degraded. Examining a map or summary showing those condition classes would help a manager develop a relative trail condition assignment. A trail condition index might also be calculated as:

$$\frac{\text{Sum of all segment values x their length}}{\text{Total trail length}}$$

Trail condition indexes calculated with this equation could be used to compare different trails or to determine threshold values for good, fair, degraded, or very degraded condition.

Regardless of the method used to develop the trail condition index, the results would be plotted on a graph (figure 13–6).

Figure 13–7 combines the trail value and trail condition indexes. Individual trails would be plotted on the combined index based on their priority and condition index. Trails would be assigned to one of four quadrants: high value/good condition, high value/poor condition, low value/good condition, and low value/poor condition. Figure 13–8 shows a strategy for allocating trail maintenance resources; identifying relative annual, periodic, and project-level maintenance priorities, and recommending sustainability evaluations and management alternatives for trails in low value and poor condition.

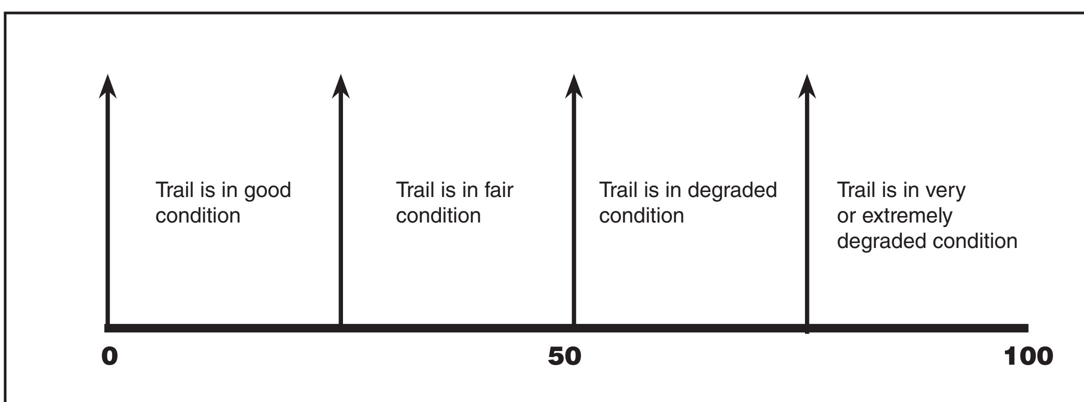


Figure 13–6—Trail condition index.

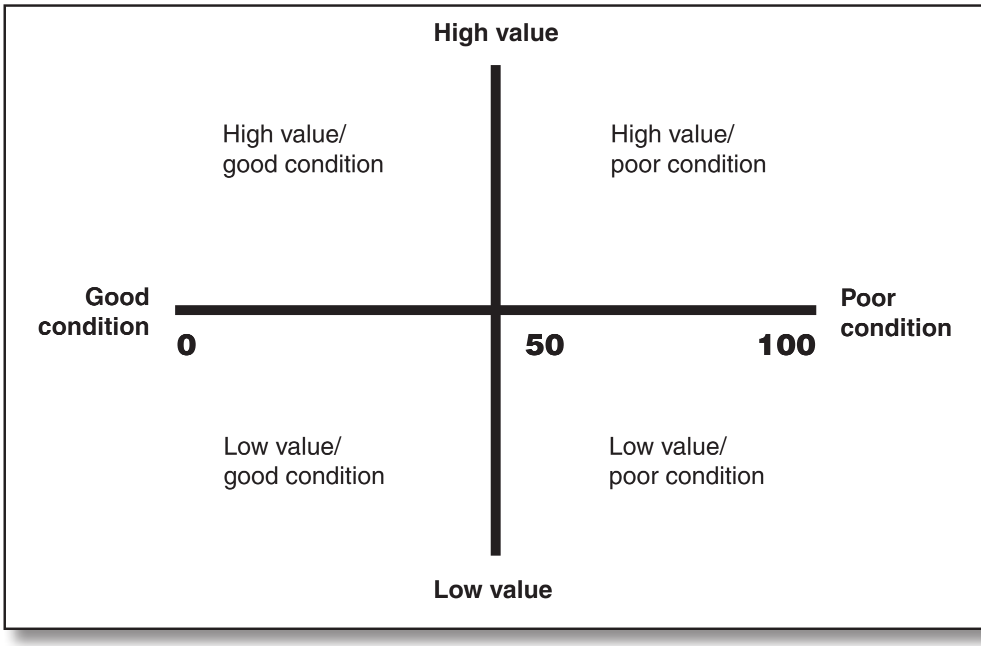


Figure 13–7—Combined trail value and trail condition indexes.

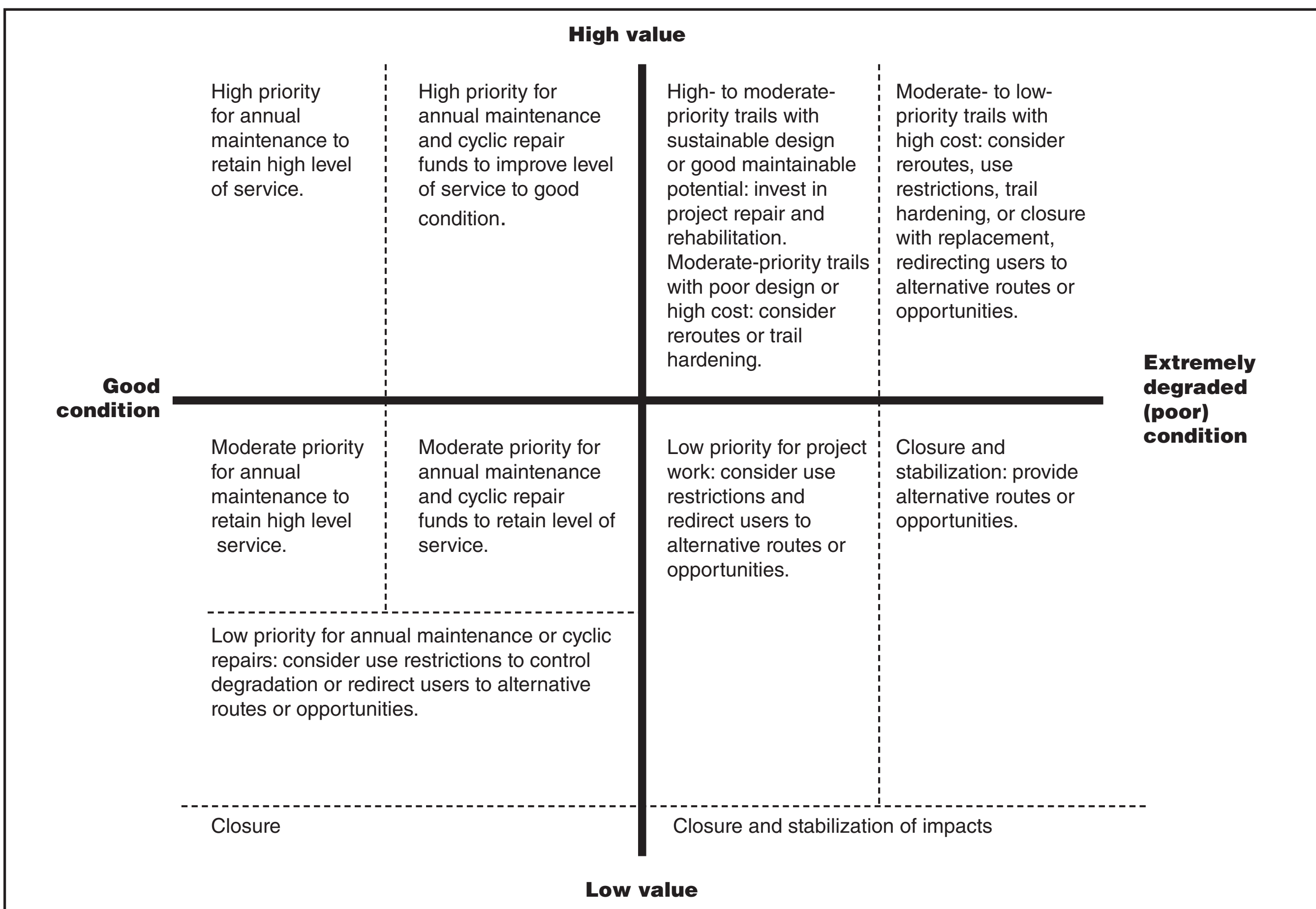


Figure 13–8—Using the combined trail value and trail condition indexes to allocate trail management resources.

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Chapter 14: Element 9—Implementation

Implementation deals with all aspects of the work for a new trail construction project or a maintenance project for an existing trail. Implementation addresses funding considerations, compliance and permitting concerns, logistics planning, job hazard analysis, and management oversight and documentation.

Funding Considerations

Constructing a new OHV trail is not cheap, but continually maintaining a poorly designed or degraded trail can be much more expensive. Whether you are constructing new trails or maintaining existing trails, it is important to work as efficiently as possible.

Heavy equipment can minimize the need for hand crews, allowing projects to be completed more quickly and less expensively. The Forest Service's Trails Unlimited enterprise unit typically fields a three-person crew equipped with a trail dozer (figure 14–1), a compact excavator (figure 14–2), and a rake and drag (figure 14–3) pulled by an ATV. The Trails Unlimited crews also use full-sized bulldozers, skid-steer loaders, and tracked carriers, depending on the requirements of the job.

Figure 14–1—A trail dozer has proven to be an efficient piece of earth-moving equipment for trail construction and maintenance.

Figure 14–2—A miniexcavator is a versatile piece of equipment for trail construction and maintenance and plays a valuable role in supporting trail dozer operations.

Figure 14–3—A spring-tooth rake is pulled by an ATV for final tread shaping.

The cost of new OHV trail construction using heavy equipment starts at about $15,000 to $20,000 a mile, but can vary considerably depending on site conditions, the length of trail being constructed, logistic difficulties, and the type and number of structures required along the alignment. Appendix K includes project reports that document the use of heavy equipment on two Alaska trails. Both projects were constructed on sideslopes using sustainable trail design guidelines. Because they were laid out carefully, neither project required bridges or other structures. Direct construction costs were less than $14,000 per mile.

Maintenance and mitigation projects on existing OHV trails vary so widely that it's difficult to provide an estimated starting point. Cost will vary depending on:

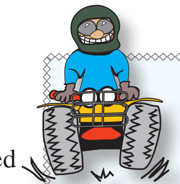
- Access
- Site conditions
- Trail character
- History of maintenance and mitigation actions
- Severity and type of degradation
- Length of trail requiring treatment
- Logistics (for example crew support and staging)
- Type and number of structures
- Length and character of reroutings
- Extent and character of rehabilitation
- Operator skill and efficiency

For maintenance projects, hand crews are required to brush overgrown vegetation, construct structures, and rehabilitate trail segments. They also may provide finishing touches in areas maintained by machines. The costs of hand crews are significant in overall project costs.

Labor costs vary depending on whether the labor is provided by internal staff, seasonal employees, volunteers, or contract crews. Projects often rely on volunteer crews. While these crews come free, they may not come cheap. Consider all costs, including the costs of supervision, training, and logistic support.

Trail hardening can also inflate costs dramatically. In Alaska, trail hardening projects have cost from $11,000 to more than $291,000 per mile. The "OHV Trail Project Comparison Chart" in appendix K includes costs for 12 Alaska trail construction and maintenance projects completed between 2001 and 2007.

Typically, funding for trail projects is an internal process managed by the agency itself. Each organization has its own process for handling funding requests, allocating funds, and managing budgets. OHV trail managers should apply their agency's funding system when implementing maintenance and construction projects. OHV managers may be able to apply for Federal, State, and private grants for trail projects.



Guides to the Forest Service's Volunteer Program

The Forest Service Volunteer Program was established in 1972 by the Volunteers in the National Forest Act. Volunteers help ensure that important interpretive and project work gets done, but they need supervision and management. In the Forest Service, volunteer coordinators provide leadership that is reflected in volunteers' attitudes and work.

The Missoula Technology and Development Center has developed:

- "Volunteers in the Forest Service: A Coordinator's Desk Guide" (http://www .fs.fed.us/t-d/pubshtmlpubs /htm09672814/ Username: t-d, Password: t-d)
- "Welcome to the Forest Service: A Guide for Volunteers" (http://www.fs.fed.us/eng/pubs/htmlpubs /htm09672813/)

These guides provide Forest Service employees and volunteers with consistent information, forms, and guidance.

Compliance and Permitting

Environmental compliance will probably be a requirement for all new construction and for any major projects that involve extensive rerouting or trail hardening. The National Environmental Policy Act (NEPA) requires preparation of an environmental assessment (EA) or environmental impact statement (EIS) for all major Federal actions. In general, any action that includes Federal funding will require some level of NEPA compliance. Depending on agency policy, regular maintenance on existing trails may fall under a categorical exclusion that simplifies NEPA compliance. Many States also require environmental review under State law. Check with your agency compliance specialist or cooperating Federal or State agencies to determine the compliance steps required for your project.

Permits may be required for construction and major maintenance projects that affect wetlands, coastal zones, water quality, fish passage, or wildlife habitat. Check with local Federal and State environmental protection agencies for permit requirements. Some States have clearinghouses to simplify the permitting process.

Appendix K includes a brief (and incomplete) summary of compliance and permitting requirements.

Logistics Planning

A logistics plan pays off when it's time to implement a project. The logistics plan provides details of all major elements of a project, and can serve as a handy checklist to track and monitor progress. Appendix K includes a blank "OHV Trail Project Logistics Plan." A project's major tasks might include:

Task A—Final construction layout and flagging with ground control, integrated drainage, and marked clearing limits

Task B—Timber and heavy brush clearing

Task C—Tread construction, trail dozer/excavator operations

Task D—30-foot bridge construction, MP 15+35

Task E—25-foot bridge construction, MP 340+16

Task F—Trail hardening, 2-meter-wide, unfilled porous pavement, 84 feet long, from MP 480+12 to MP 480+96

Organizing the project into major tasks can simplify management and allow for resources to be allocated efficiently throughout the project.

Other valuable project support documents include detailed task descriptions and crew instruction sheets. Appendix K includes examples of instruction sheets for clearing and construction crews.

Job Hazard Analysis

Each project task has a different mix of employees, equipment, supplies, materials, and hazards (figures 14–4 and 14–5). Most agencies have developed their own job hazard analysis (JHA) process. The Forest Service JHA lists individual tasks and identifies associated hazards and possible abatement actions. The abatement actions include engineering controls, substitution (using a less hazardous approach), administrative controls, and personal protective equipment (PPE). Appendix L includes two examples of Forest Service JHAs, one for TRACS field surveys at the Chugach National Forest in Alaska and one for trail maintenance and construction at the Sawtooth National Recreation Area in Idaho. The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) addresses JHAs in a 46-page booklet available at http://www.osha.gov/Publications/osha3071.pdf.

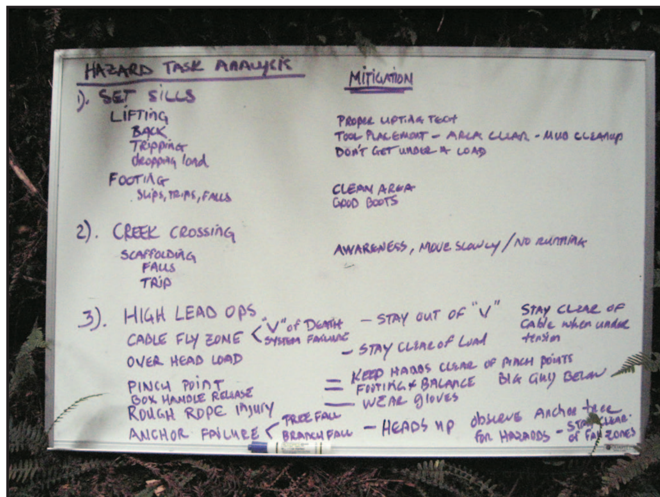


Figure 14–4—A tailgate safety session before work on primary job tasks will help instill a safe working attitude.

Figure 14–5—Job hazards vary by project task. The hazards associated with chain saw use are different than operating equipment, working on a construction line, or conducting a helicopter slinging operation. Note the use of appropriate personal protection equipment (PPE) for this sawing operation—hardhat, gloves, chaps, and ear and eye protection.

Management Oversight and Documentation

Management oversight is a critical element of any trail project. This oversight is necessary to monitor a crew's compliance with layout, clearing, and construction design specifications and to make sure the crew completes the work safely and efficiently.

For Federal contracts, the agency's contracting officer is responsible for management oversight. Contracts require an inspection report showing compliance with bid items and specifications. The inspection report is a legal document that can be cited in any dispute hearing or litigation action. Contract officers often recruit an onsite inspector or a contract officer's representative to monitor projects and complete the inspection reports. The OHV trail manager may play this role.

The "OHV Trail Project Oversight Checklist" in appendix K is organized by major phases of the project and can be modified for specific projects.

Excavation Volumes

Why use heavy equipment for new trail construction? Table 14–1 and figure 14–6 show the volumes of material that must be moved for full bench construction (500 cubic yards is about 650 tons of material).

Table 14–1—Excavation volumes in cubic yards per 100 linear feet (Shields 2009).

Bench width (feet)	Excavation type[1]	Sideslope (percent)					
		15	25	35	45	[2]55	[2]70
4	BE	4.44	7.41	10.40	13.30	16.30	20.70
	BsE	1.51	5.69	16.20	43.50	33.50	93.10
	Total	6.00	13.10	26.60	56.80	49.80	14.00
6	BE	10.00	16.70	23.30	30.00	36.70	46.70
	BsE	3.40	12.80	36.50	97.80	75.40	209.00
	Total	13.40	29.50	59.80	128.00	112.00	256.00
8	BE	17.80	29.60	41.50	53.30	65.20	83.00
	BsE	6.00	22.80	65.00	174.00	134.00	372.00
	Total	23.80	52.40	107.00	227.00	199.00	455.00
10	BE	27.80	46.30	64.80	83.30	102.00	NA
	BsE	9.40	35.60	101.00	272.00	210.00	NA
	Total	37.20	81.90	166.00	355.00	312.00	NA
12	BE	40.00	66.70	93.30	120.00	NA	NA
	BsE	13.60	51.20	146.00	391.00	NA	NA
	Total	53.60	118.00	240.00	511.00	NA	NA

Note: Backslope is 1½:1 up to 50-percent sideslope, 1:1 for sideslopes steeper than 50 percent.
[1]BE = Bench excavation, BsE = backslope excavation.
[2]Sideslopes steeper than 60 percent typically require backslope retaining walls.

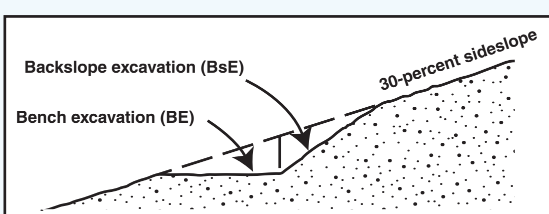
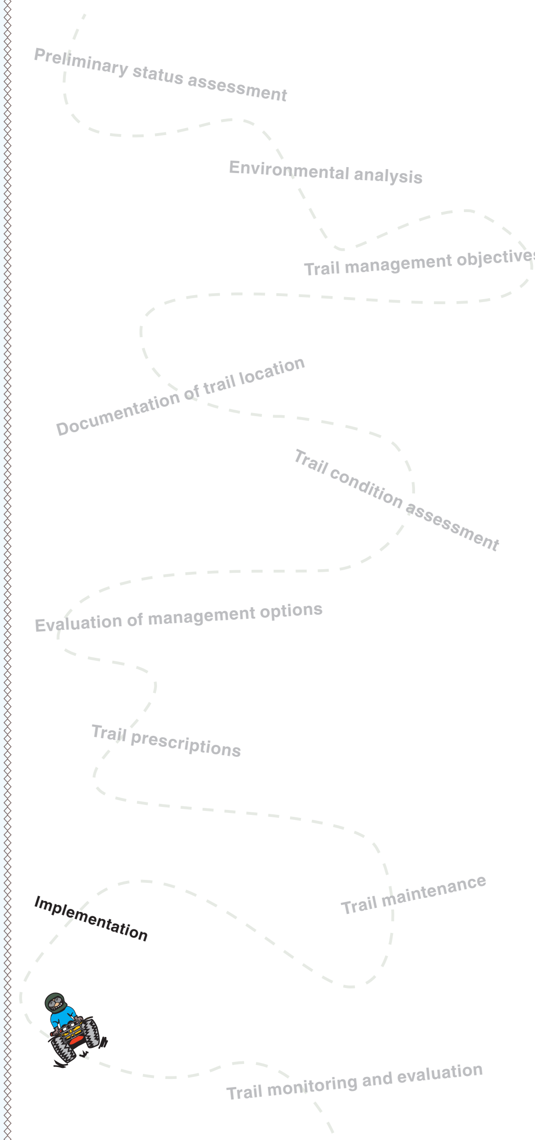


Figure 14–6—Terms used when estimating excavation volumes for full bench construction.



Chapter 15: Element 10—Trail Monitoring and Evaluation

Periodic trail monitoring and evaluation provide data that can be used to review changes in trail condition and to assess the adequacy of maintenance. Trail managers can review the results of their on-the-ground actions and make adjustments. The types of monitoring discussed here include compliance monitoring, identifying maintenance needs, and trail condition monitoring. Appendix D includes a list of best management practices for monitoring OHV use.

Compliance Monitoring

Compliance monitoring documents basic compliance with trail design and sustainability standards, providing feedback to the trail manager on trail maintenance status, sustainable trail design, and the TMO's applicability to actual trail conditions.

Knowing whether a trail complies with its design parameters lets the trail manager know whether the trail is providing the desired level of service. Minor failures to comply with design parameters, such as reductions in cross slope or vegetation regrowing inside clearing limits, can be corrected with regular maintenance. The development of social trails or widened or braided trail segments may indicate major problems. These problems can occur when the trail does not lead to features trail users are trying to access, when users detour around degraded segments of trail, or when the trail does not meet users' needs and expectations. The trail design, level of maintenance, or changes in use characteristics may need to be reviewed. For instance, a change in use characteristics would suggest that the TMO may need to be reviewed and possibly updated.

An assessment of design parameters and sustainable trail design guidelines can be conducted relatively easily because only items that are not in compliance need to be noted. The assessment can also be conducted by technicians with limited trails expertise because they are comparing existing trail conditions against a set of measurable standards.

Figure 15–1 shows a sample data collection sheet that could be used to quickly document noncompliance with TMO design parameters and sustainable trail design guidelines. A companion monitoring effort could identify use characteristics such as use types, volume of use, intensity of use, and season of use. Although some use information could be extracted from trail logbooks, it's important to supplement that information by monitoring use at the site.

Data Collection Sheet

Trail name **Date** **Inspectors**

Target design grade______(percent) **Maximum grade**_____(percent) **Trail width**______ **Cross slope**______(percent) **Clearing limits** **width**____(feet) **height**_____(feet)

TRAILWAY				Item of noncompliance				Sustainable design					Notes
Starting waypoint	Ending waypoint	Length	Grade	Trail width	Cross slope	Clearing limits	Off-trail impacts	Contour	Controlled grade	Integrated drainage	Full bench	Durable tread	

Figure 15–1—A data collection sheet for documenting noncompliance with TMO parameters and guidelines.

Identifying Maintenance Needs

When the Forest Service's TRACS system (see "Element 7—Trail Prescriptions") is used, trail experts traverse the trail to assess compliance with TMO design parameters and identify maintenance or improvement needs. The TRACS system also satisfies the compliance monitoring objectives. The Forest Service specifies the interval for conducting TRACS surveys based on trail class. Class 5 trails (the most developed trails) should be surveyed every 5 years. Less developed trails are surveyed less frequently.

Once an initial TRACS survey has been completed, it becomes the baseline inventory, condition assessment, and prescription for the trail. Subsequent TRACS surveys, called validation surveys, evaluate current trail conditions against the TMO and national standards, document any changes in condition, document the results of maintenance conducted between monitoring periods, and identify changes that might be needed in prescriptions. Validation surveys can be conducted with eTRACS data recorders that allow quick comparison between baseline data and current field conditions. The eTRACS system allows data to be updated quickly onsite and transferred to the agency's database later. Comparing the baseline survey and validation surveys allows trail condition trends and the maintenance methods, intensity, and frequency to be assessed.

Trail Condition Monitoring

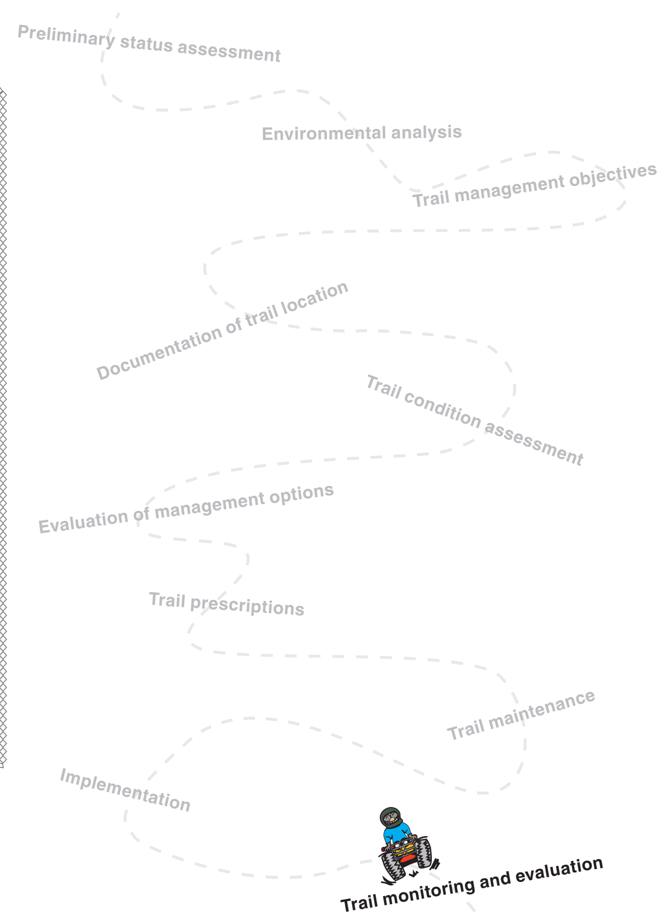
Trail condition monitoring tracks changes in trail conditions over time. A variety of techniques can be used, including:

Stratified Point Sampling

A stratified point sampling technique for trails was developed in the mid 1980s (Connery and others 1986), adapted for NPS OHV trails in Alaska during the 1990s (Happe and others 1998), and further refined by researchers at the Virginia Polytechnic Institute and State University under Jeffrey Marion (Marion and Leung 2001). This technique uses a random sample of specific locations where

Monitoring Frequency

Regardless of the technique, OHV trails should be monitored regularly—at least once every 5 to 10 years—depending on levels of use, trail conditions, and other environmental factors. The frequency could be increased if significant environmental values are at risk, but enough time should pass between monitoring so that any changes are meaningful and not just short-term changes related to weather patterns or changes reflecting the subjectivity of field inventory crews. To the extent possible, monitoring inventories should be conducted at roughly the same time of year when soil surface moisture levels are similar to those during earlier inventories.



detailed measurements are taken of trail cross section, associated vegetation cover, and other site features. The distribution of the sample points is stratified by use type, terrain, vegetation community, or other factors. The sample sites are resampled periodically.

This technique uses recognized statistical evaluation methods, collects quantifiable measurements, and is repeatable. The monitoring can be done by technicians who do not need to be trail experts. The technique quantifies changes in a scientific manner and allows trends to be projected, but provides little additional information on segment management for trail managers. Acquiring a statistically valid sample can be expensive if the trail environment is highly stratified (when a trail has a wide variation in attributes such as terrain, soils, grades, and use characteristics). This technique is best used for academic studies or to meet formal monitoring compliance requirements of NEPA or a lawsuit.

Ground Photopoints

Photopoints are a popular, cheap, and simple monitoring technique often used to document qualitative changes in trail conditions over time. Representative trail segments or locations of special interest are identified and permanently marked. GPS coordinates are recorded to help photographers find the locations. The sites are visited periodically so photos can be taken showing the same area. Photographers who carry copies of the original photos to the field will find it easier to take new pictures that accurately show changes. When the old and new photos are compared, the changes can be quite dramatic. This method can be used by almost anyone and requires little or no trail expertise.

One limitation of the photopoint technique is that it is difficult to describe condition trends for a trail scientifically based on a few photopoints. Photopoints are useful only to document conditions and make general qualitative observations at specific sites. Trail conditions could be misrepresented by a few dramatic or blasé photos. The MTDC tech tip "Camera with Altitude for Wilderness Site Monitoring" (http://www.fs.fed.us/t-d/pubs/htmlpubs/htm04232301/, Username: t-d, Password: t-d) has advice on taking photos for photopoints.

Remote Sensing

Another way of identifying condition trends is to compare aerial or satellite photographs of the same area taken at different times. With satellite imagery available through such Web sites as Google Earth, the opportunities for using this technique have improved dramatically. While the detail of tread surface conditions may be limited by the resolution of the images or by vegetation cover, changes in certain features may be evident. These include:

- Trail extensions
- Development of social trails, spurs, and cutoffs
- Significant widening or narrowing of the tread surface
- Development or abandonment of trail braids
- Development of campsites, parking areas, or play areas
- Installation of trail improvements such as bridges or hardened trail segments
- Vegetation changes on and alongside the trail
- Significant erosion or deposition areas (possibly including discharge plumes into bodies of water)
- Stream capture by trail alignments, changes at ford sites, or other hydrologic alterations
- Extensive surface water ponding along the tread
- Other noticeable modifications in the trail alignment and the surrounding landscape, such as landfills

Because the images may include a 100-percent sample of visible trail data, the analysis has scientific validity. Imagery also can be used to identify sites that require further ground examination, allowing general observations and interpretations to be verified on the ground.

Changes between images can be detected by sophisticated computer programs that overlay the images or with special scale-matching stereoscopes. Simpler methods include:

- Printing photos to the same scale and transferring data between them with transparent overlays
- Digitizing or scanning annotated overlays and modifying their scales to match one another
- Visually sketching in changes observed on a newer image to the older image.

Repeat Condition Assessments

Repeat condition assessments have not been extensively tested, but they would provide detailed data on changes in trail physical condition over time. A baseline condition assessment would be conducted and the trail would be reinventoried after a specified interval, using the same data dictionary that was used in the original condition assessment. This technique would document changes along the entire length of a trail, essentially a 100-percent sample. The accurate spatial and statistical dataset could be used to document changes in trail condition and to project trends.

One of four methods could be used. The first method **updates the original map.** Technicians return to the field with the original dataset on printed maps and attribute tables. When they return to trail segments identified in the original inventory, they review the original attribute values and change values as new conditions warrant.

Another method would be to **conduct a completely separate inventory** using the same data dictionary. The technicians would traverse the trail and identify their own segment breaks and assign attribute values independent of the original baseline inventory. The primary point of comparison between the two datasets would be the summary statistics, such as condition categories and the lengths of trail segments with various attribute values. Direct comparisons between individual trail segments would be more difficult because technicians may identify different segment breaks during the two inventories.

Datasets collected by this method would be completely independent—the technicians would not be biased by previous methods of data acquisition. The disadvantages would be the time required to conduct the inventory, the need to postprocess the new data, and the wide variation likely in identification of trail segments and interpretation of attributes. These disadvantages would generally outweigh the advantages of this method unless completely independent, unbiased monitoring was required.

A third method uses a **hybrid point sampling technique.** Random sample points are distributed along the trail. The allocation of points could be stratified by one or more attributes, such as trail grade category or trail surface character. The dataset also could be stratified based on physiographic characteristics such as flat lands and uplands, or based on administrative units such as trail classes or land ownership.

Stratification generally increases the accuracy and utility of an analysis, but requires a larger sample size. Because variation between trail segments would have been documented in the original dataset, a statistician could develop a sampling protocol for any level of accuracy that was needed.

The sample points are distributed along the trail alignment and a table is generated with the physical coordinates (latitude and longitude) of the sample points and their segment attribute values. Technicians go directly to each sample point along the route, review the attribute class values of the segment, and make changes to reflect new conditions. This method generates a statistical summary of change at the sample sites that could indicate condition trends for the entire trail.

Because this method studies just a sample of sites, it does not document changes for every individual segment along the trail. The method could be used to indicate the need for maintenance, the need to modify maintenance intervals, or the need to change the intensity of maintenance.

A fourth method relies on a **geodatabase comparison.** In this technique, a dataset from a previous inventory effort could be compared to current conditions. The dataset would be checked out of the GIS, loaded in a mobile mapping system and taken to the field. Mapping techniques would make changes to the dataset based on observed conditions. The dataset would be checked back into the GIS and a report run showing the changes between the two datasets This method is similar to the first, "updating the original map," but takes advantage of current technology.

Monitoring To Evaluate Maintenance Level

Determining trail condition trends over long periods is the key to evaluating whether the level of maintenance is adequate. The objective of all maintenance should be to stabilize or improve trail conditions. In general, if the trail condition trend is negative, maintenance levels are not adequate; if the trend is stable, they are about right; and if the tread is positive, the maintenance levels are adequate or may be excessive—at least for the use and weather conditions experienced between the monitoring periods.

Maintenance levels are only one factor affecting the trail condition and its trend. Other factors include changes in use characteristics, the quality of trail design and construction, and weather and climate conditions. Figure 15–2 illustrates the relationship of these factors to trail maintenance. The OHV trail manager must step back and evaluate the entire trails environment to determine whether the maintenance program is adequate.

The most appropriate monitoring type, technique, and method depend on the objectives of monitoring and the availability of resources, such as equipment, time, funding, and expertise. Table 15–1 compares monitoring techniques to help trail managers select the most appropriate approach.

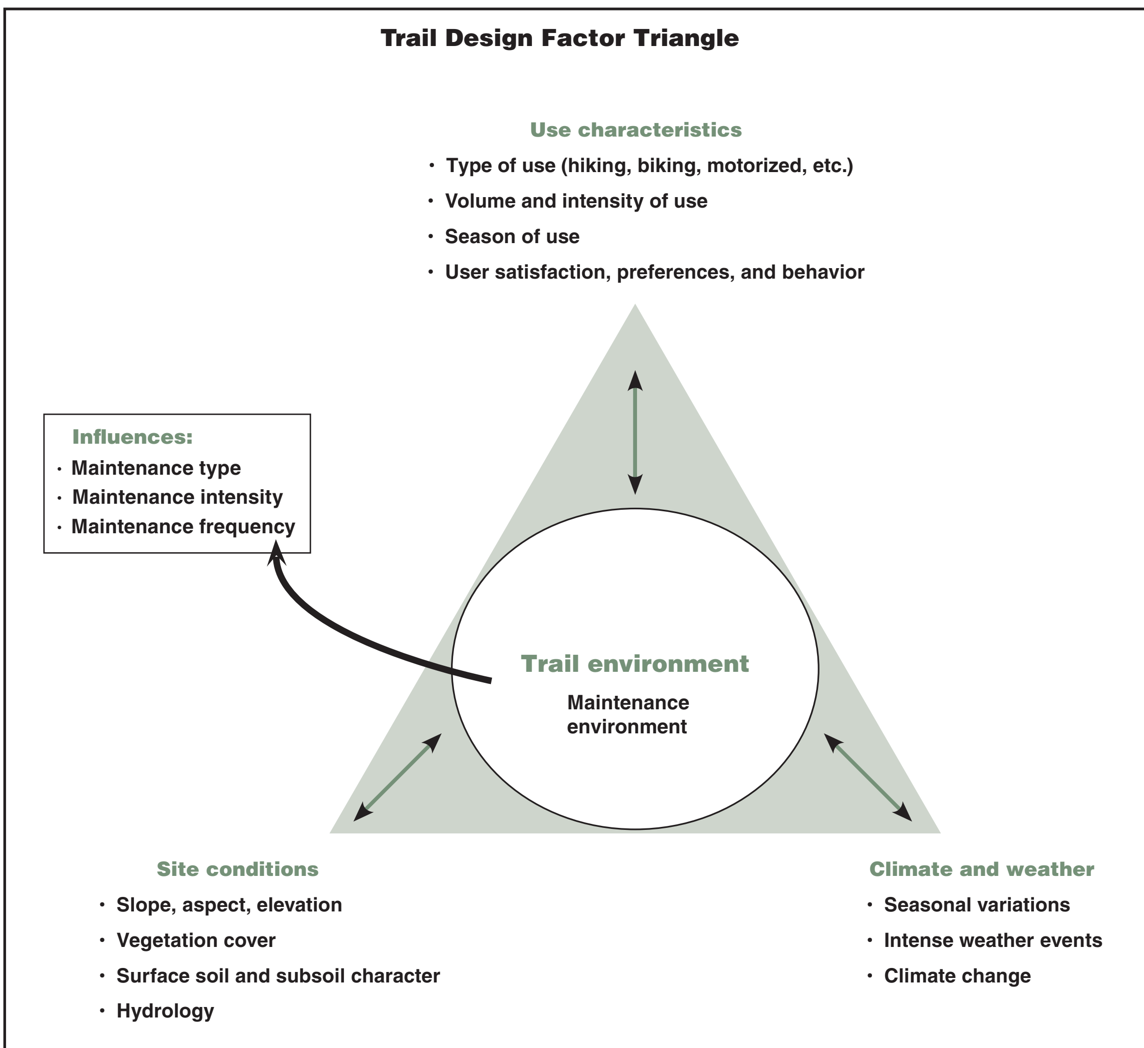


Figure 15–2—Trail design factors influence trail maintenance type, intensity, and frequency.

Table 15–1—Comparison of monitoring techniques.

Monitoring techniques	**Review of TMO specifications provided?** (S = sometimes)	**Review of sustainable elements provided?** (S = sometimes)	**Provides indicators of condition trend**	**Trails expertise required**	**GPS expertise required**	**GIS expertise required**	**Photo interpretation skills required**	**Statistical methods required**	**Access to computer software needed**	**Access to agency hardware/ software needed**	**Quantified dataset**	**Statistically valid dataset**	**Qualitative dataset**	**Method: T = transverse P = point**	**Provides detail for maintenance actions**	**Technical complexity**	**Relative equipment requirements**	**Relative time investment**	**Relative cost**
General Monitoring																			
Design specifications/ sustainable compliance	Yes	Yes	Yes	Low	No	No	No	No	No	No	Yes	Yes	No	T	Partial	Low	Low	Moderate	Moderate
Maintenance needs	Yes	No	Yes	High	No	No	No	No	Moderate	Yes	Yes	Yes	No	T	Yes	Moderate	Moderate	High	High
Trail condition monitoring																			
Stratified point	Sample only	Sample only	Sample only	No	Moderate	No	No	Yes	Low	No	Yes	Yes	No	P	No	Moderate	Low	Moderate	High
Ground photo point	No	No	Varies	No	Moderate	No	No	No	No	No	No	No	Yes	P	No	Low	Low	Low	Low
Remote sensing	No	Partial	Yes	Low	No	Moderate	Moderate	No	Moderate	No	Yes	Yes	Yes	Varies	Partial	Moderate	Low to moderate	Moderate	Moderate
Repeat condition assessments																			
Updates	S	S	Yes	Low	Moderate	Moderate	No	No	Moderate	No	Yes	Yes	No	T	Partial	Moderate	High	Moderate	Moderate
Independent	S	S	Yes	Moderate	High	High	No	No	High	No	Yes	Yes	No	T	Partial	High	High	High	Very high
Hybrid point	Sample only	Sample only	Sample only	Low	Moderate	Low	No	Yes	High	No	Yes	Yes	No	P	No	Moderate	Moderate	Low	Moderate
Geodatabase comparison	S	S	Yes	Low	Moderate	Moderate	No	No	Moderate	Yes	Yes	Yes	No	T	Partial	Moderate	High	Moderate	Moderate

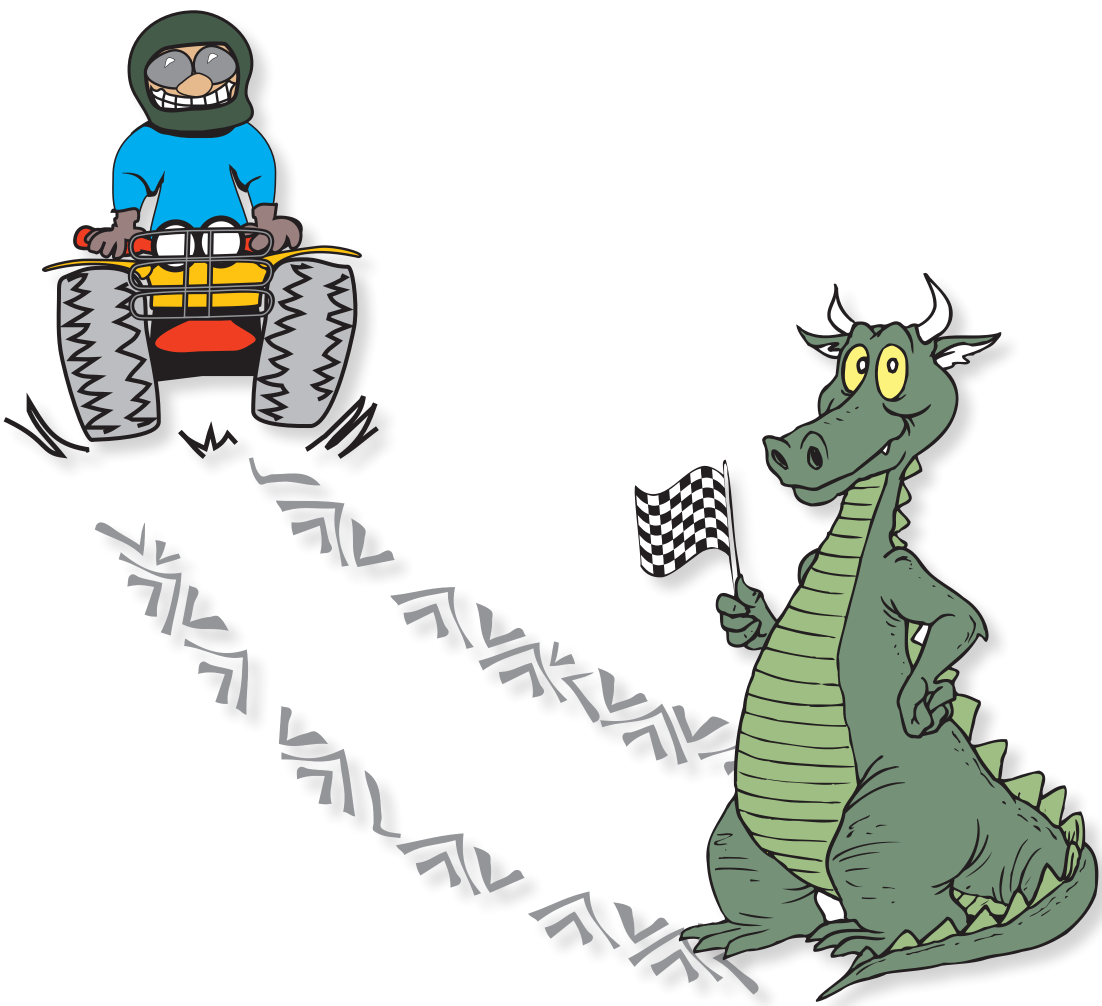
Chapter 16: Closing Thoughts

The sustainability concepts, trail fundamentals, and the 10 elements of the management framework in this guidebook provide a systematic approach to OHV trail management. Managing OHV use is one of the most challenging natural resource issues facing land managers today. The need to accommodate the growing demand for motorized recreation in the face of conflicts with other uses and impacts to resource values is pushing the limits of trail science. Traditionally, trail management was the province of a handful of skilled backcountry maintenance workers. Today, trail resources concern a wide range of trail users, environmentalists, natural resource professionals, and technical specialists.

Trail management is fast becoming a field of study in its own right—Trail Ecology, if you will. Amateur and professional trail ecologists or trailologists are beginning to apply scientific principles to all areas of trail management. Their goal is to integrate trails harmoniously with the local environment and provide outstanding sustainable trail recreation opportunities. Such opportunities will help meet the needs and expectations of diverse user groups while protecting resource values for the next century.

This framework was developed to help trail managers corral the OHV management dragon. The author hopes it has provided some insight into the nature of OHV trails and some tools to help keep the beast at bay.

Happy herding and happy trails!



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Chapter 17: References and Additional Resources

Each reference and the additional resources provide valuable information on trail design, construction methods, maintenance, or general trail management. While some may be regional in nature or focus on other types of trails, their basic concepts can readily be adapted to OHV trails.

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Additional Trail-Building Resources

Manuals

A Handbook on Trail Building and Maintenance: For National, State and local Natural Resource Managing Agencies, 1996
Stephen S. Griswold, Sequoia Natural History Association, phone: 559–565–3759

AMC's Complete Guide to Trail Building and Maintenance, 4th Edition, 2008
Appalachian Mountain Club, available for purchase at http://amcstore.outdoors.org/amcstore/ (Click on Books)
Note: Readers may enjoy an earlier version ("AMC Field Guide to Trail Building and Maintenance 2d ed.") by Robert D. Proudman and Reuben Rajala. Used copies of the 1981 guide are available through online bookstores and libraries.

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Web Sites

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Technical resources
http://www.imba.com/resources/trail_building/

Marshall University
OHV management courses
http://www.marshall.edu/muonline/ohv.asp

National Off-Highway Vehicle Conservation Council
Technical resources
http://www.nohvcc.org/

National Trails Training Partnership
Training and technical resources
http://www.americantrails.org/nttp/

Professional Trail Builders Association
Technical resources
http://www.trailbuilders.org/resources/

Trails Unlimited
Consulting and trail training opportunities
http://www.fs.fed.us/trailsunlimited/

U.S. Department of Agriculture, Forest Service
Recreation program OHV Web site
http://www.fs.fed.us/recreation/programs/ohv/

U.S. Department of the Interior, National Park Service Rivers, Trails, and Conservation Assistance Program
Technical resources and assistance
http://www.nps.gov/ncrc/programs/rtca/

U.S. Department of the Interior, U.S. Fish and Wildlife Service
National Interagency Trails Course
http://training.fws.gov/
Click on "course search" and enter "trail management" in the keyword search box

A 4½-day interagency trails training course "Trail Management: Plans, Projects and People" is offered three times a year. The course addresses achieving sustainable and accessible trails of all kinds, using the best practices of the trail management process. This collaborative process includes planning, design layout, construction, maintenance, monitoring, crew leadership, interpretation, operations, and safety. Field exercises include trail layout, construction, and maintenance techniques. The Federal Highway Administration and other Federal agencies provide annual funding for this course. Contact:

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About the Author

Kevin G. Meyer is the regional trails specialist for the National Park Service in Anchorage, AK, and a consultant for the agency's Rivers, Trails, and Conservation Assistance Program (RTCA). He earned a bachelor's degree in soil science and natural resources management from the University of Wisconsin-Madison in 1976 and a master's degree in forestry from Colorado State University in 1985. Kevin has worked in the area of surface protection and resource management for the U.S. Department of the Interior in Alaska since 1977. Since 2000, he has focused on responding to the challenges of OHV management in Alaska's sensitive environments. He is the author of a 2002 MTDC report: "Managing Degraded Off-Highway Vehicle Trails in Wet, Unstable, and Sensitive Environments." He is an active consultant for RTCA throughout Alaska, conducts trails training sessions for Alaska Trails, a Statewide nonprofit organization, and has developed numerous sustainable trails training programs, technical trails publications, and management techniques. Kevin is a nationally recognized expert on trail hardening methodologies for permafrost and wetlands. In 2008, he received a U.S. Department of the Interior 2008 National Cooperative Conservation Award. In 2009, he was invited to join the instructor pool for the national interagency trails training course, "Trail Management: Plans, Projects and People."

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Meyer, Kevin G. 2010. A comprehensive framework for off-highway vehicle trail management. Tech. Rep. 1023–2804–MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 320 p.

In this report, Regional Trails Specialist Kevin Meyer shares his years of experience addressing surface protection, resource management, and OHV issues on Federal, State, and private lands. He describes sustainability concepts, trail fundamentals, and 10 management elements for a systematic, scientific approach to OHV management. Twelve appendixes cover a range of information from best management practices to examples of trail work.

Keywords: all-terrain vehicles, ATVs, BLM, geographic information systems, GIS, global positioning systems, GPS, motorized recreation, National Park Service, NPS, off-road vehicles, OHVs, planning, recreation management, safety at work, sustainability, trail maintenance, U.S. Department of Agriculture Forest Service, U.S. Department of the Interior, U.S. Fish and Wildlife Service, utility-terrain vehicles, UTVs

Additional single copies of this document may be ordered from:

USDA Forest Service
Missoula Technology and Development Center
5785 Hwy. 10 West
Missoula, MT 59808–9361
Phone: 406–329–3978
Fax: 406–329–3719
Email: wo_mtdc_pubs@fs.fed.us

Electronic copies of MTDC's documents are available on the Internet at:

http://www.fs.fed.us/eng/t-d.php

Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, CDs, DVDs, and videos on their internal computer networks at:

http://fsweb.mtdc.wo.fs.fed.us/search/

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